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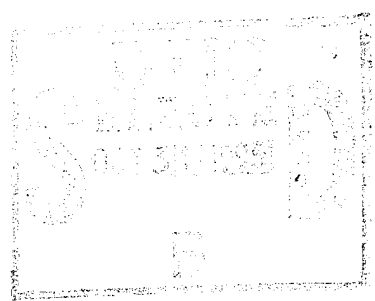
Proof of Crossplane Symmetry for a Conical Navier-Stokes
Solver

by

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Abstract

A formal proof is given for the symmetry of a conical Navier-Stokes equation solver that has been employed in the computation of vortex asymmetries. The conical Navier-Stokes equations are presented as developed from the generalized coordinate three-dimensional Navier-Stokes equation approach. The solver is then discussed in detail. The proof is first sketched to clarify what must be shown to demonstrate symmetry. The details of the implicit and explicit side symmetry relations are then presented using in part the MACSYMA symbolic manipulation expert system.

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Introduction

This report was prompted by the need to demonstrate symmetry for a conical Navier-Stokes algorithm used in studies of vortex asymmetry about cones at incidence. This issue arises because vortex asymmetry has been observed to occur "naturally" for the conical Navier-Stokes equations (i.e., without external perturbations) whereas it is apparently not observed in similar three-dimensional Navier-Stokes calculations. Vortex asymmetry is found in two of three possible solutions to the nonlinear equation set. These solutions have been found to be stable to perturbations whereas the third (symmetric) solution is thought to be unstable. In fact, the asymmetric solution is found after the solver has converged partially to the symmetric solution. It is felt that roundoff error perturbations excite the instability and redirect the solver to the asymmetric solution. However, it is also conceivable that some algorithm related asymmetries exist which produce the same result, thereby negating any conclusions drawn from solutions obtained by these solvers. It is therefore imperative that the algorithm be symmetric before computational arithmetic is employed.

The following sections report the governing equations that form the basis of this solver, the numerical method used and finally the symmetry proof.

Governing Equations

The conical thin-layer Navier-Stokes equations are obtained from discretizations of the generalized coordinate three-dimensional thin-layer Navier-Stokes equations. A grid is chosen such that the ξ -direction is along rays from the cone tip. Properties are then assumed constant along these rays. In their most general sense the thin-layer Navier-Stokes equations may be written

$$\frac{\partial Q}{\partial \tau} + \frac{\partial F_i}{\partial \xi} + \frac{\partial (G_i - S_v)}{\partial \eta} + \frac{\partial H_i}{\partial \zeta} = 0 \quad (1)$$

where

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ e \end{bmatrix} \quad F_i = \frac{1}{J} \begin{bmatrix} \rho U \\ \rho u U + \xi_x p \\ \rho v U + \xi_y p \\ \rho w U + \xi_z p \\ (e+p)U \end{bmatrix} \quad G_i = \frac{1}{J} \begin{bmatrix} \rho V \\ \rho u V + \eta_x p \\ \rho v V + \eta_y p \\ \rho w V + \eta_z p \\ (e+p)V \end{bmatrix}$$

$$H_i = \frac{1}{J} \begin{bmatrix} \rho W \\ \rho u W + \zeta_x p \\ \rho v W + \zeta_y p \\ \rho w W + \zeta_z p \\ (e+p)W \end{bmatrix} \quad S_v = \frac{M_\infty \mu}{Re_L J} \begin{bmatrix} 0 \\ \eta_x \sigma_x + \eta_y \tau_{xy} + \eta_z \tau_{xz} \\ \eta_x \tau_{xy} + \eta_y \sigma_y + \eta_z \tau_{yz} \\ \eta_x \tau_{xz} + \eta_y \tau_{yz} + \eta_z \sigma_z \\ \bar{u} S_{v_2} + \bar{v} S_{v_3} + \bar{w} S_{v_4} - \eta_x q_x - \eta_y q_y - \eta_z q_z \end{bmatrix}$$

$$U = \xi_x u + \xi_y v + \xi_z w$$

$$V = \eta_x u + \eta_y v + \eta_z w$$

$$W = \zeta_x u + \zeta_y v + \zeta_z w$$

with \bar{u} , \bar{v} & \bar{w} as average velocities between cells and $\sigma_x, \sigma_y, \sigma_z, \tau_{xy}, \tau_{xz}$ & τ_{yz} having their usual definitions.

A steady form of the above equations is found by neglecting the time derivative of the conserved variables. The resulting equations are solved on a single crossflow (η, ζ) plane grid in which the ξ -direction lines are rays from the cone tip or origin. The conical equations result when constant property boundary conditions are enforced in the radial direction, as described later in the numerical method section. It should be noted that these boundary conditions are necessary only because a three-dimensional solver has been modified to form the conical solver. Boundary conditions are needed only on the surface and far field boundaries for the conical Navier-Stokes equations.

Numerical Method

An implicit upwind symmetric factorization finite volume scheme was employed to solve the above equations. The basic algorithm consists of the implicit or left hand side (LHS) and the explicit or right hand side (RHS) in the form

$$LHS(Q^n) \Delta^n Q = RHS(Q^n) \quad (2)$$

An iteration proceeds from a known Q^n to Q^{n+1} by solving equation (2) for $\Delta^n Q$ and using

$$Q^{n+1} = Q^n + \Delta^n Q$$

RHS

The RHS is differenced using Roe's [Roe] flux difference splitting (FDS) and the Van Albada [VanAl] limiter through Van Leer's [VanLe] MUSCL approach. A convenient way of writing the FDS is presented by Vatsa, Thomas and Wedan [VTW], who detail the contribution of the ξ -direction fluxes as

$$\frac{\partial F}{\partial \xi} = \frac{F_{i+1/2} - F_{i-1/2}}{\Delta \xi}$$

where

$$F_{i+1/2} = \frac{1}{2} [F(Q_L) + F(Q_R) - |\tilde{A}|(Q_R - Q_L)]_{i+1/2}$$

and Q_L and Q_R are functions of neighboring points as described later in the limiter section and $|\tilde{A}|$ is the diagonalized matrix

$$|\tilde{A}| = T|\Lambda|T^{-1}$$

formed from the Roe averaged variables (a function of Q_L and Q_R) with Λ the diagonal eigenvalue matrix, T the matrix of left eigenvectors of A and T^{-1} the matrix of right eigenvectors of A . Note that these matrices are also used for the LHS but in

a slightly different form. The actual matrices can be found in several places including the Vatsa, Thomas and Wedan reference or through the MACSYMA outputs to be presented in a later section.

Flux Limiters

Of interest at this point is how Q_L and Q_R are chosen. In this work Van Leer's [VanLe] MUSCL approach is utilized with the Van Albada [VanAl] flux limiter. The MUSCL approach can be utilized with many limiters, as such, it can be written as

$$Q_L = Q_i + \frac{1}{4} \left\{ (1 - \kappa) \hat{\Delta}_{i-1/2} + (1 + \kappa) \tilde{\Delta}_{i+1/2} \right\}$$

$$Q_R = Q_{i+1} - \frac{1}{4} \left\{ (1 + \kappa) \hat{\Delta}_{i+1/2} + (1 - \kappa) \tilde{\Delta}_{i+3/2} \right\}$$

The Van Albada limiter is obtained by setting $\kappa = 1$

$$Q_L = Q_i + \frac{1}{2} \tilde{\Delta}_{i+1/2}$$

$$Q_R = Q_{i+1} - \frac{1}{2} \hat{\Delta}_{i+1/2} = Q_{i+1} - \frac{1}{2} \tilde{\Delta}_{i+3/2}$$

and

$$\tilde{\Delta}_{i+1/2} = \frac{\Delta_{i-1/2} [\Delta_{i+1/2}^2 + \epsilon] + \Delta_{i+1/2} [\Delta_{i-1/2}^2 + \epsilon]}{\Delta_{i+1/2}^2 + \Delta_{i-1/2}^2 + 2\epsilon}$$

where

$$\Delta_{i+1/2} = Q_{i+1} - Q_i$$

The value of ϵ is typically taken to be a small number to avoid spurious zero divisions.

The above describes how the inviscid terms of the RHS are calculated. The viscous terms are included through central differencing of S_v . This completely describes the algorithm solved via the implicit system. Details of the algorithm can be obtained through the references or by examining the input to MACSYMA for the symmetry checks.

LHS

The LHS can be described by discretizing equation (1) using a simple implicit scheme

$$\frac{\Delta^n Q}{\Delta \tau} + \frac{\partial F_i^{n+1}}{\partial \xi} + \frac{\partial (G_i^{n+1} - S_v^{n+1})}{\partial \eta} + \frac{\partial H_i^{n+1}}{\partial \zeta} = 0 \quad (3)$$

Subtracting the n -level steady terms from both sides and dropping the viscous terms from the LHS gives

$$\begin{aligned} \frac{\Delta^n Q}{\Delta \tau} + \frac{\partial (F_i^{n+1} - F_i^n)}{\partial \xi} + \frac{\partial (G_i^{n+1} - G_i^n)}{\partial \eta} + \frac{\partial (H_i^{n+1} - H_i^n)}{\partial \zeta} \\ = - \left[\frac{\partial F_i^n}{\partial \xi} + \frac{\partial (G_i^n - S_v^n)}{\partial \eta} + \frac{\partial H_i^n}{\partial \zeta} \right] = - RHS^n \end{aligned} \quad (4)$$

and linearizing the inviscid fluxes about the n^{th} level

$$F_i^{n+1} \approx F_i^n + \left. \frac{\partial F_i}{\partial Q} \right|_n \Delta Q^n = F_i^n + A^n \Delta^n Q \quad (5)$$

$$G_i^{n+1} \approx G_i^n + \left. \frac{\partial G_i}{\partial Q} \right|_n \Delta Q^n = G_i^n + B^n \Delta^n Q \quad (6)$$

$$H_i^{n+1} \approx H_i^n + \left. \frac{\partial H_i}{\partial Q} \right|_n \Delta Q^n = H_i^n + C^n \Delta^n Q \quad (7)$$

The above describes how the inviscid terms of the RHS are calculated. The viscous terms are included through central differencing of S_v . This completely describes the algorithm solved via the implicit system. Details of the algorithm can be obtained through the references or by examining the input to MACSYMA for the symmetry checks.

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Subtracting the n -level steady terms from both sides and dropping the viscous terms, S_v^{n+1} and S_v^n , from the LHS gives

$$\begin{aligned} \frac{\Delta^n Q}{\Delta \tau} + \frac{\partial (F_i^{n+1} - F_i^n)}{\partial \xi} + \frac{\partial (G_i^{n+1} - G_i^n)}{\partial \eta} + \frac{\partial (H_i^{n+1} - H_i^n)}{\partial \zeta} \\ = - \left[\frac{\partial F_i^n}{\partial \xi} + \frac{\partial (G_i^n - S_v^n)}{\partial \eta} + \frac{\partial H_i^n}{\partial \zeta} \right] = -RHS^n \end{aligned} \quad (4)$$

and linearizing the inviscid fluxes about the n^{th} level

$$F_i^{n+1} \approx F_i^n + \left. \frac{\partial F_i}{\partial Q} \right|_n \Delta Q^n = F_i^n + A^n \Delta^n Q \quad (5)$$

$$G_i^{n+1} \approx G_i^n + \left. \frac{\partial G_i}{\partial Q} \right|_n \Delta Q^n = G_i^n + B^n \Delta^n Q \quad (6)$$

$$H_i^{n+1} \approx H_i^n + \left. \frac{\partial H_i}{\partial Q} \right|_n \Delta Q^n = H_i^n + C^n \Delta^n Q \quad (7)$$

results in

$$\frac{\Delta^n Q}{\Delta \tau} + \frac{\partial}{\partial \xi}(A^n \Delta^n Q) + \frac{\partial}{\partial \eta}(B^n \Delta^n Q) + \frac{\partial}{\partial \zeta}(C^n \Delta^n Q) = -RHS^n$$

or, in operator notation

$$\left[\frac{I}{\Delta \tau} + \left(\frac{\partial A}{\partial \xi} \right)^n + \left(\frac{\partial B}{\partial \eta} \right)^n + \left(\frac{\partial C}{\partial \zeta} \right)^n \right] \Delta^n Q = -RHS^n \quad (8)$$

Finally, multiplying by $\Delta \tau$ gives

$$\left[I + \Delta \tau \left\{ \left(\frac{\partial A}{\partial \xi} \right)^n + \left(\frac{\partial B}{\partial \eta} \right)^n + \left(\frac{\partial C}{\partial \zeta} \right)^n \right\} \right] \Delta^n Q = -\Delta \tau RHS^n \quad (9)$$

where RHS^n is obtained as described above. It is important to note that the scheme is now “semi” implicit since the viscous terms are lagged. However, this does not affect the solution at convergence since it is defined as a zero RHS to machine accuracy. Next the LHS is differenced using the Steger-Warming flux vector splitting (FVS). The scheme can be written

$$\begin{aligned} \left(I + \Delta \tau \left\{ \nabla_{\xi} A^+ + \Delta_{\xi} A^- + \nabla_{\eta} B^+ + \Delta_{\eta} B^- + \nabla_{\zeta} C^+ + \Delta_{\zeta} C^- \right\} \right) \Delta^n Q \\ = -\Delta \tau RHS^n \end{aligned} \quad (10)$$

Where $A^{\pm}, B^{\pm}, C^{\pm}$ are the generalized coordinate Steger-Warming [StegWar] FVS Jacobians; $\Delta \xi, \Delta \eta, \Delta \zeta$ are assumed to be unity; and Δ_{ξ} and ∇_{ξ} , etc., are the standard two point forward and backward difference operators

$$\begin{aligned} \Delta_{\xi}(\quad) &= (\quad)_{i+1,j,k} - (\quad)_{i,j,k} \\ \nabla_{\xi}(\quad) &= (\quad)_{i,j,k} - (\quad)_{i-1,j,k} \end{aligned}$$

It should be noted that the bracketed terms are acting as operators on $\Delta^n Q$ (i.e., $\Delta_{\xi} A^- \Delta^n Q = [A^- \Delta^n Q]_{i+1,j,k} - [A^- \Delta^n Q]_{i,j,k}$). Details of the Jacobian matrices can be found in the references or can be inferred from the proof. The above produces a block

septa-diagonal system which is not easy to solve. However, the system can be approximately factored so that two block tetra-diagonal systems result

$$\begin{aligned} & \left(I + \Delta \tau \left\{ \nabla_{\xi} A^{+} + \nabla_{\eta} B^{+} + \Delta_{\eta} B^{-} \right\} \right) \\ & \left(I + \Delta \tau \left\{ \Delta_{\xi} A^{-} + \nabla_{\zeta} C^{+} + \Delta_{\zeta} C^{-} \right\} \right) \Delta^n Q = -\Delta \tau RHS^n \end{aligned} \quad (11)$$

This system can then be solved in two steps

$$\begin{aligned} & \left(I + \Delta \tau \left\{ \nabla_{\xi} A^{+} + \nabla_{\eta} B^{+} + \Delta_{\eta} B^{-} \right\} \right) Q^{*} = -\Delta \tau RHS^n \quad (12a) \\ & \left(I + \Delta \tau \left\{ \Delta_{\xi} A^{-} + \nabla_{\zeta} C^{+} + \Delta_{\zeta} C^{-} \right\} \right) \Delta^n Q = Q^{*} \quad (12b) \end{aligned}$$

by employing a block tri-diagonal solver while sweeping the ξ -direction in (η, ζ) -planes. For three dimensional problems, forward sweeps are used for equation (12a) and backward sweeps for equation (12b). It is important to note that the above system is symmetric in ζ since both C^{+} and C^{-} are in the same factor. This will become more apparent in the symmetry proof.

The conical solver uses equation (12) in a somewhat abbreviated form. That is, only one plane of cells is considered, therefore,

$$\begin{aligned} \Delta_{\xi} A^{-} & \approx -A^{-}_{ij,k} \\ \nabla_{\xi} A^{-} & \approx A^{-}_{ijk} \end{aligned}$$

This approximation essentially assumes that $\Delta^n Q=0$ for the off plane terms (although they are computed through the conical flow boundary condition.) This term can be removed to improve algorithm efficiency, but has no detrimental effect on the solution. It was retained in the current solver. In any event, it has no bearing on algorithm symmetry as will be shown in the proof.

The conical LHS is as described above and is always solved on a conical grid.

Symmetry Proof

The MACSYMA symbolic manipulation expert system was used to determine the symmetry of the above algorithm. The proof is first sketched in a general sense to provide an overview and then the details are presented.

General Proof

As presented earlier, the conical solver was developed from a generalized coordinate three dimensional solver by simplifying the algorithm when applied on a conical grid. If Cartesian coordinates are used to describe the physical space, the x-direction corresponds to the cone axis; the y-direction is vertical, such that incidence is achieved by a pitch up in the (x,y) plane; and the z-direction is orthogonal to the (x,y) plane. In the computational space the ξ -direction lines are rays from the cone tip and the (η, ζ) plane is perpendicular to the cone axis, with the η -direction normal to the axis and the ζ -direction azimuthal.

For this geometry and grid, symmetry in the crossplane requires that the mirror image grid points (i, j, k) and (i, \hat{j}, \hat{k}) at locations (x, y, z) and $(x, y, -z)$, respectively, must have

$$Q_{ijk} = MQ_{i\hat{j}\hat{k}}$$

where

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \\ e \end{bmatrix} \quad \text{and} \quad M = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Clearly, $M = M^{-1}$.

Furthermore, the metrics are related in the following manner

$$\begin{aligned}
 \left(\frac{\xi_x}{J} \right)_{ijk} &= \left(\frac{\xi_x}{J} \right)_{\hat{i}\hat{j}\hat{k}} \\
 \left(\frac{\xi_y}{J} \right)_{ijk} &= \left(\frac{\xi_y}{J} \right)_{\hat{i}\hat{j}\hat{k}} = 0 \\
 \left(\frac{\xi_z}{J} \right)_{ijk} &= \left(\frac{\xi_z}{J} \right)_{\hat{i}\hat{j}\hat{k}} = 0 \\
 \left(\frac{\eta_x}{J} \right)_{ijk} &= \left(\frac{\eta_x}{J} \right)_{\hat{i}\hat{j},\hat{k}} \\
 \left(\frac{\eta_y}{J} \right)_{ijk} &= \left(\frac{\eta_y}{J} \right)_{\hat{i}\hat{j},\hat{k}} \\
 \left(\frac{\eta_z}{J} \right)_{ijk} &= - \left(\frac{\eta_z}{J} \right)_{\hat{i}\hat{j}\hat{k}} \\
 \left(\frac{\zeta_x}{J} \right)_{ijk} &= - \left(\frac{\zeta_x}{J} \right)_{\hat{i}\hat{j}\hat{k}} \\
 \left(\frac{\zeta_y}{J} \right)_{ijk} &= - \left(\frac{\zeta_y}{J} \right)_{\hat{i}\hat{j}\hat{k}} \\
 \left(\frac{\zeta_z}{J} \right)_{ijk} &= \left(\frac{\zeta_z}{J} \right)_{\hat{i}\hat{j},\hat{k}}
 \end{aligned}$$

Hence, the cell contravariant velocities

$$\begin{aligned}
 U &= \xi_x u + \xi_y v + \xi_z w \\
 V &= \eta_x u + \eta_y v + \eta_z w \\
 W &= \zeta_x u + \zeta_y v + \zeta_z w
 \end{aligned}$$

are related as per

$$U_{ijk} = U_{\hat{i}\hat{j}\hat{k}}, \quad V_{i,j,k} = V_{\hat{i}\hat{j}\hat{k}}, \quad W_{ijk} = -W_{\hat{i}\hat{j}\hat{k}}$$

To prove symmetry we start with the assumption that the solution from the previous iteration (n-1) is symmetric (for n=1, this implies the initial condition is symmetric), hence

$$RHS^n_{ijk} = M RHS^n_{\hat{i}\hat{j}\hat{k}} \quad (13)$$

Consequently, we expect the intermediate "solution" obtained by solving equation (12a) to be symmetric

$$Q^*_{ijk} = M Q^*_{\hat{i}\hat{j}\hat{k}} \quad (14)$$

and hence, the final solution is also symmetric because the change obtained by solving equation (12b) is symmetric

$$\Delta^n Q_{ijk} = M \Delta^n Q_{\hat{i}\hat{j}\hat{k}} \quad (15)$$

RHS

Referring to equation (1) it is easy to show that a simple central difference of the RHS is symmetric since

$$\begin{aligned} F_{i,j,k} &= M F_{\hat{i}\hat{j}\hat{k}} \\ G_{i,j,k} &= M G_{\hat{i}\hat{j}\hat{k}} \\ H_{i,j,k} &= -M H_{\hat{i}\hat{j}\hat{k}} \end{aligned}$$

and because the azimuthal ordering prescribes the correspondence $(i,j,k+1)$ to $(\hat{i},\hat{j},\hat{k}-1)$ and $(i,j,k-1)$ to $(\hat{i},\hat{j},\hat{k}+1)$

$$H_{i,j,k\pm 1} = -M H_{\hat{i}\hat{j}\hat{k}\mp 1}$$

therefore,

$$\begin{aligned}\left(\frac{\partial F}{\partial \xi}\right)_{ijk} &= M \left(\frac{\partial F}{\partial \xi}\right)_{\hat{i}\hat{j}\hat{k}} \\ \left(\frac{\partial G}{\partial \eta}\right)_{ijk} &= M \left(\frac{\partial G}{\partial \eta}\right)_{\hat{i}\hat{j}\hat{k}} \\ \left(\frac{\partial H}{\partial \zeta}\right)_{ijk} &= M \left(\frac{\partial H}{\partial \zeta}\right)_{\hat{i}\hat{j}\hat{k}}\end{aligned}$$

This relationship can also be demonstrated for the flux limited Roe FDS discretization, but it is not visually apparent from the equations. It should be noted that the azimuthal ordering oddity significantly complicates the MACSYMA comparison because it requires the identification of the corresponding terms a priori, since the performance of MACSYMA is related to the complexity of the expressions. The MACSYMA derived proof for the RHS requires two steps; demonstrate symmetry for the flux limited variables and then symmetry for the remaining terms. A separate proof is given for each direction as this reduces the MACSYMA workload to a manageable size. These proofs are found in the RHS Proof section following the general proof.

LHS

The LHS expressions also contain the ζ -direction oddity, however, symmetry is easily demonstrated because the following relationships can be proved

$$A^{\pm}_{ijk} M = M A^{\pm}_{\hat{i}\hat{j}\hat{k}} \quad (16)$$

$$B^{\pm}_{ijk} M = M B^{\pm}_{\hat{i}\hat{j}\hat{k}} \quad (17)$$

$$C^{\pm}_{ijk} M = -M C^{\mp}_{\hat{i}\hat{j}\hat{k}} \quad (18)$$

In addition, we have

$$C^{\pm}_{ijk\pm 1} M = -M C^{\mp}_{\hat{i}\hat{j}\hat{k}\mp 1} \quad (19)$$

due to the azimuthal direction ordering reversal. These relations will be proven in the LHS Proof section. It should be clear that symmetry cannot be guaranteed in the algorithm unless C^+ and C^- appear in the same factor.

Given the above relationships consider equation (12a) at point (i,j,k) with the operators expanded

$$Q^*_{ijk} + \Delta\tau \left([A^+ Q^*]_{ijk} - [A^+ Q^*]_{i-1,j,k} + [B^+ Q^*]_{ijk} - [B^+ Q^*]_{i,j-1,k} + [B^- Q^*]_{i,j+1,k} - [B^- Q^*]_{i,j,k} \right) = RHS^n_{ijk} \quad (20)$$

and at the point $(\hat{i}, \hat{j}, \hat{k})$

$$Q^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau \left([A^+ Q^*]_{\hat{i}\hat{j}\hat{k}} - [A^+ Q^*]_{\hat{i}-1,\hat{j},\hat{k}} + [B^+ Q^*]_{\hat{i}\hat{j}\hat{k}} - [B^+ Q^*]_{\hat{i},\hat{j}-1,\hat{k}} + [B^- Q^*]_{\hat{i},\hat{j}+1,\hat{k}} - [B^- Q^*]_{\hat{i},\hat{j},\hat{k}} \right) = RHS^n_{\hat{i}\hat{j}\hat{k}} \quad (21)$$

Pre-multiply equation (21) by M and use equation (13) to obtain

$$MQ^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau \left([MA^+ Q^*]_{\hat{i}\hat{j}\hat{k}} - [MA^+ Q^*]_{\hat{i}-1,\hat{j},\hat{k}} + [MB^+ Q^*]_{\hat{i}\hat{j}\hat{k}} - [MB^+ Q^*]_{\hat{i},\hat{j}-1,\hat{k}} + [MB^- Q^*]_{\hat{i},\hat{j}+1,\hat{k}} - [MB^- Q^*]_{\hat{i},\hat{j},\hat{k}} \right) = RHS^n_{ijk} \quad (22)$$

Using relations (16)-(18) in equation (22) gives

$$MQ^*_{\hat{i}\hat{j}\hat{k}} + \Delta\tau \left(A^+_{ijk} MQ^*_{\hat{i}\hat{j}\hat{k}} - A^+_{i-1,j,k} MQ^*_{\hat{i}-1,\hat{j},\hat{k}} + B^+_{ijk} MQ^*_{\hat{i}\hat{j}\hat{k}} - B^+_{i,j-1,k} MQ^*_{\hat{i},\hat{j}-1,\hat{k}} + B^-_{i,j+1,k} MQ^*_{\hat{i},\hat{j}+1,\hat{k}} - B^-_{i,j,k} MQ^*_{\hat{i},\hat{j},\hat{k}} \right) = RHS^n_{ijk} \quad (23)$$

Subtracting equation (23) from (20) yields

$$[Q^*_{ijk} - MQ^*_{\hat{i}\hat{j}\hat{k}}] + \Delta\tau \left(A^+_{ijk} [Q^*_{ijk} - MQ^*_{\hat{i}\hat{j}\hat{k}}] - A^+_{i-1,j,k} [Q^*_{i-1,j,k} - MQ^*_{\hat{i}-1,\hat{j},\hat{k}}] + B^+_{ijk} [Q^*_{ijk} - MQ^*_{\hat{i}\hat{j}\hat{k}}] - B^+_{i,j-1,k} [Q^*_{i,j-1,k} - MQ^*_{\hat{i},\hat{j}-1,\hat{k}}] + B^-_{i,j+1,k} [Q^*_{i,j+1,k} - MQ^*_{\hat{i},\hat{j}+1,\hat{k}}] - B^-_{i,j,k} [Q^*_{ijk} - MQ^*_{\hat{i},\hat{j},\hat{k}}] \right) = 0$$

The first, second, fourth and seventh terms within brackets imply equation (14)

$$Q^*_{i,j,k} = MQ^*_{\hat{i}\hat{j}\hat{k}}$$

Similarly, the third term implies

$$Q^*_{i-1,j,k} = MQ^*_{\hat{i}-1,\hat{j}\hat{k}}$$

and the fifth and sixth terms imply

$$Q^*_{i,j\pm 1,k} = MQ^*_{\hat{i}\hat{j}\pm,\hat{k}}$$

which, given equations (16)-(18), proves the symmetry of the intermediate step.

Consider next the discretized equation (12b) at the point (i,j,k)

$$\begin{aligned} \Delta^n Q_{i,j,k} + \Delta\tau \left([A^-\Delta^n Q]_{i+1,j,k} - [A^-\Delta^n Q]_{i,j,k} + [C^+\Delta^n Q]_{i,j,k} - [C^+\Delta^n Q]_{i,j,k-1} \right. \\ \left. + [C^-\Delta^n Q]_{i,j,k+1} - [C^-\Delta^n Q]_{i,j,k} \right) = Q^*_{i,j,k} \end{aligned} \quad (24)$$

and at point $(\hat{i},\hat{j},\hat{k})$

$$\begin{aligned} \Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau \left([A^-\Delta^n Q]_{\hat{i}+1,\hat{j}\hat{k}} - [A^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} + [C^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} - [C^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}-1} \right. \\ \left. + [C^-\Delta^n Q]_{\hat{i}\hat{j},\hat{k}+1} - [C^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} \right) = Q^*_{\hat{i}\hat{j}\hat{k}} \end{aligned} \quad (25)$$

Pre-multiply equation (25) by M and use equation (14) to obtain

$$\begin{aligned} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau \left([MA^-\Delta^n Q]_{\hat{i}+1,\hat{j}\hat{k}} - [MA^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} + [MC^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} \right. \\ \left. - [MC^+\Delta^n Q]_{\hat{i}\hat{j}\hat{k}-1} + [MC^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}+1} - [MC^-\Delta^n Q]_{\hat{i}\hat{j}\hat{k}} \right) = Q^*_{i,j,k} \end{aligned} \quad (26)$$

Using relations (16)-(19) in equation (26) gives

$$\begin{aligned} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} + \Delta\tau \left(A^-_{i+1,j,k} M\Delta^n Q_{\hat{i}+1,\hat{j}\hat{k}} - A^-_{i,j,k} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} - C^-_{i,j,k} \Delta^n Q_{\hat{i}\hat{j}\hat{k}} \right. \\ \left. + C^-_{i,j,k-1} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}-1} - C^+_{i,j,k+1} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}+1} + C^+_{i,j,k} M\Delta^n Q_{\hat{i}\hat{j}\hat{k}} \right) = Q^*_{i,j,k} \end{aligned} \quad (27)$$

Subtracting equation (27) from equation (24) yields

$$\begin{aligned}
 & [\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] \\
 & + \Delta\tau \left(A_{i+1,j,k}^- [\Delta^n Q_{i+1,j,k} - M\Delta^n Q_{\hat{i}+1,\hat{j},\hat{k}}] - A_{i,j,k}^- [\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] \right. \\
 & - C_{i,j,k}^- [\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] + C_{i,j,k+1}^- [\Delta^n Q_{i,j,k+1} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}+1}] \\
 & \left. - C_{i,j,k-1}^+ [\Delta^n Q_{i,j,k-1} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}-1}] + C_{i,j,k}^+ [\Delta^n Q_{i,j,k} - M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}] \right) = 0
 \end{aligned} \tag{28}$$

The first, third, fourth and seventh terms within brackets imply equation (15)

$$\Delta^n Q_{i,j,k} = M\Delta^n Q_{\hat{i},\hat{j},\hat{k}}$$

Similarly, the second term implies

$$\Delta^n Q_{i+1,j,k} = M\Delta^n Q_{\hat{i}+1,\hat{j},\hat{k}}$$

and the fifth and sixth terms imply

$$\Delta^n Q_{i,j,k\pm 1} = M\Delta^n Q_{\hat{i},\hat{j},\hat{k}\mp 1}$$

which is what needs to be proved. Using logic similar to that above this property holds for all (i,j,k) in the linear system and the algorithm is found to be symmetric.

RHS Proof

Proof of symmetry for the RHS requires that equation (13) be demonstrated. The RHS discretization is detailed in the Numerical Method section as it is applied to the steady form of equation (1). It is quite clear from that discussion that the discretization is rather complicated, therefore, the symmetry of the flux terms for each direction are demonstrated separately. The ξ -direction term is relatively straightforward and requires no additional manipulation, however, the η and ζ -direction terms are much more involved and the MACSYMA system was utilized.

ξ - Direction

Recall that the ξ -direction flux term may be written

$$\frac{\partial F_i}{\partial \xi} = \frac{F_{i+1/2} - F_{i-1/2}}{\Delta \xi}$$

where

$$F_{i+1/2} = \frac{1}{2} \left[F(Q_R) + F(Q_L) - |\tilde{A}|(Q_R - Q_L) \right]_{i+1/2}$$

The conical Navier-Stokes solver employs a conical grid and the assumption that properties are constant in the ξ -direction. Therefore, $Q_R - Q_L = 0$ and the scheme reverts to simple central difference in this direction. However, it is important to recognize that the flux contribution is not zero since $F(Q_R) \neq F(Q_L)$ due to the grid. In addition, for the conical grid, equation (1) gives

$$F_i = \frac{1}{J} \begin{bmatrix} \rho U \\ \rho u U + \xi_x p \\ \rho v U \\ \rho w U \\ (e + p)U \end{bmatrix}$$

In which only w has opposite sign when comparing points (i,j,k) and $(\hat{i},\hat{j},\hat{k})$.

It is therefore easy to see that

$$F_{ij,k} = MF_{\hat{i}\hat{j}\hat{k}} \quad (29)$$

Hence,

$$\left(\frac{\partial F_i}{\partial \xi} \right)_{i,j,k} = M \left(\frac{\partial F_i}{\partial \xi} \right)_{\hat{i}\hat{j}\hat{k}}$$

η -Direction

Unfortunately, it is not as easy to demonstrate symmetry for the η -direction. In this case we must show that

$$\left(\frac{\partial (G_i - S_v)}{\partial \eta} \right)_{i,j,k} = M \left(\frac{\partial (G_i - S_v)}{\partial \eta} \right)_{\hat{i}\hat{j}\hat{k}}$$

Recall that

$$\left(\frac{\partial G_i}{\partial \eta} \right)_{ij,k} = \frac{G_{i,j+1/2,k} - G_{i,j-1/2,k}}{\Delta \eta}$$

and

$$G_{i,j+1/2,k} = \frac{1}{2} [G(Q_R) + G(Q_L) - |\tilde{B}| (Q_R - Q_L)] \quad (30)$$

Then since $G_{i,j-1/2,k}$ is defined in a similar manner it is sufficient to show that

$$G_{ij+1/2,k} = M G_{\hat{i}\hat{j}+1/2,\hat{k}} \quad (31)$$

and since central differences are used for the viscous terms

$$S_{v_{ij,k}} = MS_{v_{\hat{i}\hat{j},\hat{k}}} \quad (32)$$

The MACSYMA symbolic manipulation system was utilized to demonstrate these relations. However, even in this simplified form MACSYMA requires further simplification. This can be accomplished by first demonstrating

$$\begin{aligned} Q_{R_{ij+1/2,k}} &= M Q_{R_{\hat{i}\hat{j}+1/2,\hat{k}}} \\ Q_{L_{ij+1/2,k}} &= M Q_{L_{\hat{i}\hat{j}+1/2,\hat{k}}} \end{aligned} \quad (33)$$

and then using these results to prove equation (30). The proof is therefore separated into a proof of equation (33), followed by a proof of equation (31) and finally a proof of equation (32). These proofs are accomplished respectively through the MACSYMA scripts Gflux1.max, Gflux2.mac and Gflux3.mac whose recorded inputs and results are found in files Gflux1, Gflux2 and Gflux3 in Appendix A. Note that all of the MACSYMA routines are included in the appendix for clarity. In addition, all demonstrate a zero difference between the selected terms, therefore, symmetry is proved when a null vector or matrix results. The routines themselves were written based on the actual code using identical variable names. Because of this, a few variable names are used several times. The code variables are identified with the notation discussed earlier in the Numerical Method section. It should be clear that the proofs for each direction are sequential, therefore, the results from the first in a series are used in the following series.

Gflux1 proves that given

$$\begin{aligned} dq_{ij,k} &= \Delta_{i,j+1/2,k} = Q_{ij+1,k} - Q_{ij,k} = M(Q_{\hat{i}\hat{j}+1,\hat{k}} - Q_{\hat{i}\hat{j},\hat{k}}) = M\Delta_{\hat{i}\hat{j}+1/2,\hat{k}} = M dq_{\hat{i}\hat{j},\hat{k}} \\ dqm1_{ij,k} &= \Delta_{i,j-1/2,k} = Q_{ij,k} - Q_{ij-1,k} = M(Q_{\hat{i}\hat{j},\hat{k}} - Q_{\hat{i}\hat{j}-1,\hat{k}}) = M\Delta_{\hat{i}\hat{j}-1/2,\hat{k}} = M dqm1_{\hat{i}\hat{j},\hat{k}} \\ dqp1_{ij,k} &= \Delta_{i,j+3/2,k} = Q_{ij+2,k} - Q_{ij+1,k} = M(Q_{\hat{i}\hat{j}+2,\hat{k}} - Q_{\hat{i}\hat{j}+1,\hat{k}}) = M\Delta_{\hat{i}\hat{j}+3/2,\hat{k}} = M dqp1_{\hat{i}\hat{j},\hat{k}} \\ qp_{ij,k} &= Q_{R_{ij+1/2,k}} = Q_{ij+1,k} = M Q_{\hat{i}\hat{j}+1,\hat{k}} = M Q_{R_{\hat{i}\hat{j}+1/2,\hat{k}}} = M qp_{\hat{i}\hat{j},\hat{k}} \\ qm_{ij,k} &= Q_{L_{ij+1/2,k}} = Q_{ij,k} = M Q_{\hat{i}\hat{j},\hat{k}} = M Q_{L_{\hat{i}\hat{j}+1/2,\hat{k}}} = M qm_{\hat{i}\hat{j},\hat{k}} \end{aligned}$$

the following holds

$$\begin{aligned} sp1_{ijk} &= \hat{\Delta}_{ij+1/2,k} = M\hat{\Delta}_{\hat{i}\hat{j}+1/2,\hat{k}} = M sp2_{\hat{i}\hat{j},\hat{k}} \\ sm1_{ijk} &= \tilde{\Delta}_{ij+1/2,k} = M\tilde{\Delta}_{\hat{i}\hat{j}+1/2,\hat{k}} = M sm2_{\hat{i}\hat{j},\hat{k}} \end{aligned}$$

Note that the variables qp , qm and dq are then overwritten in the code to form higher order expressions for Q_R and Q_L using

$$\begin{aligned} qp_{ijk} &= Q_{ij+1,k} - \frac{1}{2}sp1_{ijk} = Q_{R_{ij+1/2,k}} \\ &= M(Q_{\hat{i}\hat{j}+1,\hat{k}} - \frac{1}{2}sp2_{\hat{i}\hat{j},\hat{k}}) = MQ_{R_{\hat{i}\hat{j}+1/2,\hat{k}}} \\ qp_{ijk} &= Mqp_{\hat{i}\hat{j},\hat{k}} \end{aligned} \quad (34)$$

and

$$\begin{aligned} qm_{ijk} &= Q_{ij,k} + \frac{1}{2}sm1_{ijk} = Q_{L_{ij+1/2,k}} \\ &= M(Q_{\hat{i}\hat{j},\hat{k}} + \frac{1}{2}sm2_{\hat{i}\hat{j},\hat{k}}) = MQ_{L_{\hat{i}\hat{j}+1/2,\hat{k}}} \\ qm_{ijk} &= Mqm_{\hat{i}\hat{j},\hat{k}} \end{aligned} \quad (35)$$

So that the symmetry relation for $dq = Q_R - Q_L$ is given by

$$\begin{aligned} dq_{ijk} &= qp_{ijk} - qm_{ijk} \\ &= M(qp_{\hat{i}\hat{j},\hat{k}} - qm_{\hat{i}\hat{j},\hat{k}}) \\ &= Mdq_{\hat{i}\hat{j},\hat{k}} \end{aligned} \quad (36)$$

Equations (34)-(36) are then used in Gflux2 to prove equation (31). Gflux3 completes the η -direction demonstrations by proving equation (32) using the variable gs in place of S_v .

ζ -Direction

The last direction is the most difficult because of the azimuthal ordering. It is easy to see that

$$\begin{aligned} k-2 &\leftrightarrow \hat{k}+2 \\ k-1 &\leftrightarrow \hat{k}+1 \\ k &\leftrightarrow \hat{k} \\ k+1 &\leftrightarrow \hat{k}-1 \\ k+2 &\leftrightarrow \hat{k}-2 \end{aligned}$$

Once again, the desired symmetry property is

$$\left(\frac{\partial H_i}{\partial \zeta} \right)_{i,j,k} = M \left(\frac{\partial H_i}{\partial \zeta} \right)_{\hat{i},\hat{j},\hat{k}}$$

where

$$\left(\frac{\partial H_i}{\partial \zeta} \right)_{ij,k} = \frac{H_{i,j,k+1/2} - H_{i,j,k-1/2}}{\Delta \zeta}$$

and Roe's FDS gives

$$H_{i,j,k+1/2} = \frac{1}{2} \left[H(Q_R) + H(Q_L) - |\tilde{C}| (Q_R - Q_L) \right]_{j,k+1/2} \quad (37)$$

Therefore, the symmetry relation that must be proved is

$$H_{ij,k+1/2} = -M H_{\hat{i},\hat{j},\hat{k}-1/2} \quad (38)$$

Once again, the first proof, Hflux1, shows that given

$$\begin{aligned}
 dq_{ij,k} &= \Delta_{ij,k+1/2} = Q_{ij,k+1} - Q_{ij,k} = M(Q_{\hat{i}\hat{j}\hat{k}-1} - Q_{\hat{i}\hat{j}\hat{k}}) = -M\Delta_{\hat{i}\hat{j}\hat{k}-1/2} = -Mdq_{\hat{i}\hat{j}\hat{k}-1} \\
 dqp_{ij,k} &= \Delta_{ij,k+3/2} = Q_{ij,k+2} - Q_{ij,k+1} = M(Q_{\hat{i}\hat{j}\hat{k}-2} - Q_{\hat{i}\hat{j}\hat{k}-1}) = -M\Delta_{\hat{i}\hat{j}\hat{k}-3/2} = -Mdq_{\hat{i}\hat{j}\hat{k}-1} \\
 dqm_{ij,k} &= \Delta_{ij,k-1/2} = Q_{ij,k} - Q_{ij,k-1} = M(Q_{\hat{i}\hat{j}\hat{k}} - Q_{\hat{i}\hat{j}\hat{k}+1}) = -M\Delta_{\hat{i}\hat{j}\hat{k}+1/2} = -Mdqp_{\hat{i}\hat{j}\hat{k}-1} \\
 qp_{ij,k} &= Q_{ij,k+1} = M Q_{\hat{i}\hat{j}\hat{k}-1} = Mqm_{\hat{i}\hat{j}\hat{k}-1} \\
 qm_{ij,k} &= Q_{ij,k} = M Q_{\hat{i}\hat{j}\hat{k}} = Mqp_{\hat{i}\hat{j}\hat{k}-1}
 \end{aligned}$$

the following holds

$$\begin{aligned}
 spl_{ij,k} &= \hat{\Delta}_{ij,k+1/2} = -M\hat{\Delta}_{\hat{i}\hat{j}\hat{k}-1/2} = -Msm2_{\hat{i}\hat{j}\hat{k}-1} \\
 sml_{ij,k} &= \tilde{\Delta}_{ij,k+1/2} = -M\tilde{\Delta}_{\hat{i}\hat{j}\hat{k}-1/2} = -Msp2_{\hat{i}\hat{j}\hat{k}-1}
 \end{aligned}$$

Then since

$$\begin{aligned}
 qp_{ij,k} &= Q_{ij,k+1} - \frac{1}{2}spl_{ij,k} = Q_{R_{ij,k+1/2}} \\
 &= M(Q_{\hat{i}\hat{j}\hat{k}-1} + \frac{1}{2}sm2_{\hat{i}\hat{j}\hat{k}-1}) = M Q_{L_{\hat{i}\hat{j}\hat{k}-1/2}} \\
 qp_{ij,k} &= Mqm_{\hat{i}\hat{j}\hat{k}-1} \quad (39)
 \end{aligned}$$

similarly

$$\begin{aligned}
 qm_{ij,k} &= Q_{ij,k} + \frac{1}{2}sm_{ij,k} \\
 &= M(Q_{\hat{i}\hat{j}\hat{k}} - \frac{1}{2}sp2_{\hat{i}\hat{j}\hat{k}-1}) \\
 qm_{ij,k} &= Mqp_{\hat{i}\hat{j}\hat{k}-1} \quad (40)
 \end{aligned}$$

So the symmetry relation for $dq = Q_R - Q_L$ is given by

$$\begin{aligned}
 dq_{i,j,k} &= qp_{ij,k} - qm_{i,j,k} \\
 &= M(qm_{\hat{i}\hat{j}\hat{k}-1} - qp_{\hat{i}\hat{j}\hat{k}-1}) \\
 &= -Mdq_{\hat{i}\hat{j}\hat{k}-1}
 \end{aligned} \tag{41}$$

Equations (39)-(41) are then used in Hflux2 to prove equation (38).

Equations (29), (31), (32) and (38) collectively prove equation (13) and symmetry is demonstrated from the RHS.

LHS Proof

The LHS proof is somewhat simpler to describe because a major portion of it has been presented in the General Proof section. Equations (16) - (18) must be proved to demonstrate the symmetry of the LHS. IN addition, the expressions to be evaluated are considerably more complicated than their RHS counterparts. Because of this the eigenvalues were included in a less general form (i.e., without absolute values) for specific sub- and supersonic cases.

Again the MACSYMA symbolic manipulation routine was used and the resulting scripts are included in Appendix A. The files have the following naming convention

$A^+_{ijk} M = M A^+_{\hat{i}, \hat{j}, \hat{k}}$	- apsup - apsub	- supersonic - subsonic
$A^-_{ijk} M = M A^-_{\hat{i}, \hat{j}, \hat{k}}$	- amsup - amsub	- supersonic - subsonic
$B^+_{ijk} M = M B^+_{\hat{i}, \hat{j}, \hat{k}}$	- bpsup - bpsub	- supersonic - subsonic
$B^-_{ijk} M = M B^-_{\hat{i}, \hat{j}, \hat{k}}$	- bmsup - bmsub	- supersonic - subsonic
$C^+_{ijk} M = -M C^-_{\hat{i}, \hat{j}, \hat{k}}$	- ccup1 - ccsub1	- supersonic - subsonic

Note that only one set of identities must be shown for the ζ -direction since the inverse is included in those presented. It should be recognized that sub- and supersonic flows can occur in both the plus and minus coordinate directions. These cases were tested and identical results were obtained. They were deleted from the current report to save space. The interested reader can verify the proof by simple alterations to the MACSYMA scripts included in the appendix.

Given the above proofs the symmetry properties of the LHS are established and hence the algorithm is shown to be symmetric for conical grids.

Summary

The symmetry of a conical Navier-Stokes equation solver was proved through the use of analytical and symbolic techniques. The MACSYMA symbolic manipulation software was utilized. MACSYMA routines are included to allow the interested reader to verify the results.

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Appendix A

- GFLUX1
- GFLUX2
- GFLUX3
- HFLUX1
- HFLUX2
- APSUP
- APSUB
- AMSUP
- AMSUB
- BPSUP
- BPSUB
- BMSUP
- BMSUB
- CCSUP1
- CCSUB1

```

(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) g:matrix([0],[0],[0],[0],[0])$
(C5) gijk:matrix([0],[0],[0],[0],[0])$
(C6) ghatijk:matrix([0],[0],[0],[0],[0])$
(C7) sp:matrix([0],[0],[0],[0],[0],[0])$
(C8) null:matrix([0],[0],[0],[0],[0],[0])$
(C9) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C10) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C11) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C12) sp1:matrix([0],[0],[0],[0],[0],[0])$
(C13) sp2:matrix([0],[0],[0],[0],[0],[0])$
(C14) sm1:matrix([0],[0],[0],[0],[0],[0])$
(C15) sm2:matrix([0],[0],[0],[0],[0],[0])$
(C16) ax:etx$
(C17) ay:ety$
(C18) az:etz$
(C19) dq:matrix([rp1-r],[rup1-ru],[rvp1-rv],[rwp1-rw],[ep1-e],[pp1
-p])$
(C20) dqm1:matrix([r-rm1],[ru-rum1],[rv-rvm1],[rw-rwm1],[e-em1],[p
-pm1])$
(C21) dqp1:matrix([rp2-rp1],[rup2-rup1],[rvp2-rvp1],[rwp2-rwp1],[e
p2-ep1],[pp2-pp1])$
(C22) qp:matrix([rp1],[rup1],[rvp1],[rwp1],[ep1],[pp1])$
(C23) qm:matrix([r],[ru],[rv],[rw],[e],[p])$
(C24) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C25) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C26) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C27) for i:1 thru 6 do
sm1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C28) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C29) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C30) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C31) for i:1 thru 6 do
sp1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C32) m:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-1
,0,0],[0,0,0,0,1,0]
,[0,0,0,0,0,1])$
(C33) ax:etx$
(C34) ay:ety$
(C35) az:-etz$
(C36) dq:m.dq$
(C37) dqm1:m.dqm1$
(C38) dqp1:m.dqp1$
(C39) qp:m.qp$
(C40) qm:m.qm$

```

```
(C41) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C42) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C43) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C44) for i:1 thru 6 do
sm2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C45) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C46) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C47) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C48) for i:1 thru 6 do
sp2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C49) diff1:sp1-m.sp2$
(C50) diff1:ratexpand(diff1);

(D50)

(C51) diff2:sm1-m.sm2$
(C52) diff2:ratexpand(diff2);

(D52)

(C53) closefile(gflux1)$
```

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(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) g:matrix([0],[0],[0],[0],[0])$
(C5) gijk:matrix([0],[0],[0],[0],[0])$
(C6) ghatijk:matrix([0],[0],[0],[0],[0])$
(C7) sp:matrix([0],[0],[0],[0],[0],[0])$
(C8) dq:matrix([0],[0],[0],[0],[0])$
(C9) null:matrix([0],[0],[0],[0],[0],[0])$
(C10) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C11) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C12) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C13) spl:matrix([0],[0],[0],[0],[0])$
(C14) sp2:matrix([0],[0],[0],[0],[0])$
(C15) sm1:matrix([0],[0],[0],[0],[0])$
(C16) sm2:matrix([0],[0],[0],[0],[0])$
(C17) ax:etx$
(C18) ay:ety$
(C19) az:etz$
(C20) axt:ax/sada$
(C21) ayt:ay/sada$
(C22) azt:az/sada$
(C23) dq:matrix([dq1],[dq2],[dq3],[dq4],[dq5])$
(C24) qp:matrix([qp1],[qp2],[qp3],[qp4],[qp5],[qp6])$
(C25) qm:matrix([qm1],[qm2],[qm3],[qm4],[qm5],[qm6])$
(C26) axt:ax/sada$
(C27) ayt:ay/sada$
(C28) azt:az/sada$
(C29) e1:tt*sada$
(C30) e4:e1+csad$
(C31) e5:e1-csad$
(C32) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C33) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C34) a:q1/(sqrt(2)*c)$
(C35) c1:0.5*rqrq$
(C36) c2:c*c/gm1$
(C37) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C38) phi:0.5*gm1*rqrq$
(C39) c2:c*c$
(C40) b:1/(sqrt(2)*rc)$

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```

(C41) c1:1-phi/c2$
(C42) c3:gm1/c2$
(C43) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
),
b*gm1])$
(C44) sp:bl.dq$
(C45) sp2:be1.sp$
(C46) sp:bl.dq$
(C47) sm2:be2.sp$
(C48) g:br.sm2-br.sp2$
(C49) t1:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C50) g[1]:qm[1]*t1+g[1]$
(C51) g[2]:qm[2]*t1+ax*qm[6]+g[2]$
(C52) g[3]:qm[3]*t1+ay*qm[6]+g[3]$
(C53) g[4]:qm[4]*t1+az*qm[6]+g[4]$
(C54) g[5]:(qm[5]+qm[6])*t1+g[5]$
(C55) t1:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C56) gijk[1]:0.5*(qp[1]*t1+g[1])$
(C57) gijk[2]:0.5*(qp[2]*t1+ax*qp[6]+g[2])$
(C58) gijk[3]:0.5*(qp[3]*t1+ay*qp[6]+g[3])$
(C59) gijk[4]:0.5*(qp[4]*t1+az*qp[6]+g[4])$
(C60) gijk[5]:0.5*((qp[5]+qp[6])*t1+g[5])$
(C61) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C62) m2:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-
1,0,0],
[0,0,0,0,1,0],[0,0,0,0,0,1])$
(C63) ax:etx$
(C64) ay:ety$
(C65) az:-etz$
(C66) axt:ax/sada$
(C67) ayt:ay/sada$
(C68) azt:az/sada$
(C69) rw:-rw$
(C70) rwp1:-rwp1$
(C71) rwp2:-rwp2$
(C72) rwm1:-rwm1$
(C73) dq:m.dq$
(C74) qp:m2.qp$
(C75) qm:m2.qm$
(C76) q4:-q4$
(C77) e1:tt*sada$

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(C78) e4:e1+csad$
(C79) e5:e1-csad$
(C80) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C81) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C82) a:q1/(sqrt(2)*c)$
(C83) c1:0.5*rqrq$
(C84) c2:c*c/gm1$
(C85) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C86) phi:0.5*gm1*rqrq$
(C87) c2:c*c$
(C88) b:1/(sqrt(2)*rc)$
(C89) c1:1-phi/c2$
(C90) c3:gm1/c2$
(C91) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
)],
b*gm1)])$
(C92) sp:bl.dq$
(C93) sp2:be1.sp$
(C94) sp:bl.dq$
(C95) sm2:be2.sp$
(C96) g:br.sm2-br.sp2$
(C97) tl:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C98) g[1]:qm[1]*tl+g[1]$
(C99) g[2]:qm[2]*tl+ax*qm[6]+g[2]$
(C100) g[3]:qm[3]*tl+ay*qm[6]+g[3]$
(C101) g[4]:qm[4]*tl+az*qm[6]+g[4]$
(C102) g[5]:(qm[5]+qm[6])*tl+g[5]$
(C103) tl:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C104) ghatijk[1]:0.5*(qp[1]*tl+g[1])$

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(C105) ghatijk[2]:0.5*(qp[2]*tl+ax*qp[6]+g[2])$
(C106) ghatijk[3]:0.5*(qp[3]*tl+ay*qp[6]+g[3])$
(C107) ghatijk[4]:0.5*(qp[4]*tl+az*qp[6]+g[4])$
(C108) ghatijk[5]:0.5*((qp[5]+qp[6])*tl+g[5])$
(C109) diff:gijk-m.ghatijk$
(C110) diff:ratexpand(diff);

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(D110)

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(C111) closefile(gflux2)$

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(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) gsjk:matrix([0],[0],[0],[0],[0])$
(C5) gshijk:matrix([0],[0],[0],[0],[0])$
(C6) ax:etx$
(C7) ay:ety$
(C8) az:etz$
(C9) axt:ax/sada$
(C10) ayt:ay/sada$
(C11) azt:az/sada$
(C12) ra:.5*(r+rp1)$
(C13) pa:.5*(p+pp1)$
(C14) emu:(gam*abs(pa/ra))**0.666$
(C15) cons:fsmach/rel$
(C16) rpr:pr*emu$
(C17) vav:0.5*(volp1+vol)$
(C18) u2:rup1/rp1-ru/r$
(C19) v2:rvp1/rp1-rv/r$
(C20) w2:rwp1/rp1-rw/r$
(C21) t2:gam*(pp1/rp1-p/r)$
(C22) sigx:0.667*emu*cons*(2.*u2*ax-v2*ay-w2*az)/vav$
(C23) sigy:0.667*emu*cons*(2.*v2*ay-u2*ax-w2*az)/vav$
(C24) sigz:0.667*emu*cons*(2.*w2*az-u2*ax-v2*ay)/vav$
(C25) txy:emu*cons*(u2*ay+v2*ax)/vav$
(C26) txz:emu*cons*(u2*az+w2*ax)/vav$
(C27) tyz:emu*cons*(v2*az+w2*ay)/vav$
(C28) qx:-cons*rpr*rgml*t2*ax/vav$
(C29) qy:-cons*rpr*rgml*t2*ay/vav$
(C30) qz:-cons*rpr*rgml*t2*az/vav$
(C31) gsjk[1,1]:0.0$
(C32) gsjk[2,1]:ax*sigx+ay*txy+az*txz$
(C33) gsjk[3,1]:ax*txy+ay*sigy+az*tyz$
(C34) gsjk[4,1]:ax*txz+ay*tyz+az*sigz$
(C35) ua:0.5*(rup1/rp1+ru/r)$
(C36) va:0.5*(rvp1/rp1+rv/r)$
(C37) wa:0.5*(rwp1/rp1+rw/r)$
(C38) gsjk[5,1]:ua*gsjk[2,1]+va*gsjk[3,1]+wa*gsjk[4,1]-qx*ax-q
y*ay-qz*az$
(C39) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C40) ax:etx$
(C41) ay:ety$
(C42) az:-etz$
(C43) axt:ax/sada$
(C44) ayt:ay/sada$
(C45) azt:az/sada$
(C46) rw:-rw$
(C47) rwp1:-rwp1$
(C48) rwml:-rwml$
(C49) ra:.5*(r+rp1)$
(C50) pa:.5*(p+pp1)$
(C51) emu:(gam*abs(pa/ra))**0.666$

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(C52) cons:fsmach/rel$
(C53) rpr:pr*emu$
(C54) vav:0.5*(volp1+vol)$
(C55) u2:rup1/rp1-ru/r$
(C56) v2:rvp1/rp1-rv/r$
(C57) w2:rwp1/rp1-rw/r$
(C58) t2:gam*(pp1/rp1-p/r)$
(C59) sigx:0.667*emu*cons*(2.*u2*ax-v2*ay-w2*az)/vav$
(C60) sigy:0.667*emu*cons*(2.*v2*ay-u2*ax-w2*az)/vav$
(C61) sigz:0.667*emu*cons*(2.*w2*az-u2*ax-v2*ay)/vav$
(C62) txy:emu*cons*(u2*ay+v2*ax)/vav$
(C63) txz:emu*cons*(u2*az+w2*ax)/vav$
(C64) tyz:emu*cons*(v2*az+w2*ay)/vav$
(C65) qx:-cons*rpr*rgm1*t2*ax/vav$
(C66) qy:-cons*rpr*rgm1*t2*ay/vav$
(C67) qz:-cons*rpr*rgm1*t2*az/vav$
(C68) gshijk[1,1]:0.0$
(C69) gshijk[2,1]:ax*sigx+ay*txy+az*txz$
(C70) gshijk[3,1]:ax*txy+ay*sigy+az*tyz$
(C71) gshijk[4,1]:ax*txz+ay*tyz+az*sigz$
(C72) ua:0.5*(rup1/rp1+ru/r)$
(C73) va:0.5*(rvp1/rp1+rv/r)$
(C74) wa:0.5*(rwp1/rp1+rw/r)$
(C75) gshijk[5,1]:ua*gshijk[2,1]+va*gshijk[3,1]+wa*gshijk[4,1]-qx*
ax-qy*ay-qz*az$
(C76) diff:gsijk-m.gshijk$
(C77) diff:ratexpand(diff);

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(D77)

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(C78) closefile(gflux3)\$

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(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) h:matrix([0],[0],[0],[0],[0])$
(C5) hijk:matrix([0],[0],[0],[0],[0])$
(C6) hhatijk:matrix([0],[0],[0],[0],[0])$
(C7) null:matrix([0],[0],[0],[0],[0],[0])$
(C8) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C9) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C10) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C11) sp1:matrix([0],[0],[0],[0],[0],[0])$
(C12) sp2:matrix([0],[0],[0],[0],[0],[0])$
(C13) sm1:matrix([0],[0],[0],[0],[0],[0])$
(C14) sm2:matrix([0],[0],[0],[0],[0],[0])$
(C15) ax:ztx$
(C16) ay:zty$
(C17) az:ztz$
(C18) dq:matrix([rp1-r],[rup1-ru],[rvp1-rv],[rwp1-rw],[ep1-e],[pp1
-p])$
(C19) dqm1:matrix([r-rm1],[ru-rum1],[rv-rvm1],[rw-rwm1],[e-em1],[p
-pm1])$
(C20) dqp1:matrix([rp2-rp1],[rup2-rup1],[rvp2-rvp1],[rwp2-rwp1],[e
p2-ep1],[pp2-pp1])$
(C21) qp:matrix([rp1],[rup1],[rvp1],[rwp1],[ep1],[pp1])$
(C22) qm:matrix([r],[ru],[rv],[rw],[e],[p])$
(C23) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C24) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C25) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C26) for i:1 thru 6 do
sm1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C27) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C28) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C29) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C30) for i:1 thru 6 do
sp1[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C31) m:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-1
,0,0],[0,0,0,0,1,0]
,[0,0,0,0,0,1])$
(C32) ax:-ztx$
(C33) ay:-zty$
(C34) az:ztz$
(C35) dqo:dq$
(C36) dqm1o:dqm1$
(C37) dqp1o:dqp1$
(C38) qpo:qp$
(C39) qmo:qm$
(C40) dq:-M.dqo$

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(C41) dqm1:-M.dqp1o$
(C42) dqp1:-M.dqm1o$
(C43) qp:M.qm$
(C44) qm:M.qp$
(C45) for i: 1 thru 6 do
xy2[i]: dqm1[i]*(dq[i]*dq[i]+eps)$
(C46) for i:1 thru 6 do
x2y[i]: dq[i]*(dqm1[i]*dqm1[i]+eps)$
(C47) for i:1 thru 6 do
xpy[i]: dqm1[i]*dqm1[i] + dq[i]*dq[i]$
(C48) for i:1 thru 6 do
sm2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C49) for i: 1 thru 6 do
xy2[i]: dqp1[i]*(dq[i]*dq[i]+eps)$
(C50) for i:1 thru 6 do
x2y[i]: dq[i]*(dqp1[i]*dqp1[i]+eps)$
(C51) for i:1 thru 6 do
xpy[i]: dqp1[i]*dqp1[i] + dq[i]*dq[i]$
(C52) for i:1 thru 6 do
sp2[i]:(x2y[i]+xy2[i])/(xpy[i]+2*eps)$
(C53) diff1:sp1+m.sm2$
(C54) diff1:ratexpand(diff1);

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(D54)

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(C55) diff2:sm1+m.sp2$
(C56) diff2:ratexpand(diff2);

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(D56)

(C57) closefile(hflux1)\$

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(C3) diff:matrix([0],[0],[0],[0],[0])$
(C4) h:matrix([0],[0],[0],[0],[0])$
(C5) hijk:matrix([0],[0],[0],[0],[0])$
(C6) hhatijk:matrix([0],[0],[0],[0],[0],[0])$
(C7) sp:matrix([0],[0],[0],[0],[0],[0])$
(C8) dq:matrix([0],[0],[0],[0],[0])$
(C9) null:matrix([0],[0],[0],[0],[0],[0])$
(C10) xy2:matrix([0],[0],[0],[0],[0],[0])$
(C11) x2y:matrix([0],[0],[0],[0],[0],[0])$
(C12) xpy:matrix([0],[0],[0],[0],[0],[0])$
(C13) sp1:matrix([0],[0],[0],[0],[0])$
(C14) sp2:matrix([0],[0],[0],[0],[0])$
(C15) sm1:matrix([0],[0],[0],[0],[0])$
(C16) sm2:matrix([0],[0],[0],[0],[0])$
(C17) ax:ztx$
(C18) ay:zty$
(C19) az:ztz$
(C20) axt:ax/sada$
(C21) ayt:ay/sada$
(C22) azt:az/sada$
(C23) dq:matrix([dq1],[dq2],[dq3],[dq4],[dq5])$
(C24) qp:matrix([qp1],[qp2],[qp3],[qp4],[qp5],[qp6])$
(C25) qm:matrix([qm1],[qm2],[qm3],[qm4],[qm5],[qm6])$
(C26) e1:tt*sada$
(C27) e4:e1+csad$
(C28) e5:e1-csad$
(C29) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],
[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))])$
(C30) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))])$
(C31) a:q1/(sqrt(2)*c)$
(C32) c1:0.5*rqrq$
(C33) c2:c*c/gm1$
(C34) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)])$
(C35) phi:0.5*gm1*rqrq$
(C36) c2:c*c$
(C37) b:1/(sqrt(2)*rc)$
(C38) c1:1-phi/c2$
(C39) c3:gm1/c2$
(C40) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt

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*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gml),b*(c*ayt-q3*gml),b*(c*azt-q4*gml),
b*gml],
[b*(phi+c*tt),-b*(c*axt+q2*gml),-b*(c*ayt+q3*gml),-b*(c*azt+q4*gml
),
b*gml])$
(C41) sp:bl.dq$
(C42) sp2:be1.sp$
(C43) sp:bl.dq$
(C44) sm2:be2.sp$
(C45) h:br.sm2-br.sp2$
(C46) t1:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C47) h[1]:qm[1]*t1+h[1]$
(C48) h[2]:qm[2]*t1+ax*qm[6]+h[2]$
(C49) h[3]:qm[3]*t1+ay*qm[6]+h[3]$
(C50) h[4]:qm[4]*t1+az*qm[6]+h[4]$
(C51) h[5]:(qm[5]+qm[6])*t1+h[5]$
(C52) t1:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C53) hijk[1]:0.5*(qp[1]*t1+h[1])$
(C54) hijk[2]:0.5*(qp[2]*t1+ax*qp[6]+h[2])$
(C55) hijk[3]:0.5*(qp[3]*t1+ay*qp[6]+h[3])$
(C56) hijk[4]:0.5*(qp[4]*t1+az*qp[6]+h[4])$
(C57) hijk[5]:0.5*((qp[5]+qp[6])*t1+h[5])$
(C58) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0
,0,0,0,1])$
(C59) m2:matrix([1,0,0,0,0,0],[0,1,0,0,0,0],[0,0,1,0,0,0],[0,0,0,-
1,0,0],
[0,0,0,0,1,0],[0,0,0,0,0,1])$
(C60) ax:-ztx$
(C61) ay:-zty$
(C62) az:ztz$
(C63) axt:ax/sada$
(C64) ayt:ay/sada$
(C65) azt:az/sada$
(C66) dgo:dq$
(C67) qpo:qp$
(C68) qmo:qm$
(C69) dq:-m.dgo$
(C70) qp:m2.qmo$
(C71) qm:m2.qpo$
(C72) q4:-q4$
(C73) tt:-tt$
(C74) e1:tt*sada$
(C75) e4:e1+csad$
(C76) e5:e1-csad$
(C77) be1:matrix([0.5*(e1+abs(e1)),0,0,0,0],

```

```

[0,0.5*(e1+abs(e1)),0,0,0],
[0,0,0.5*(e1+abs(e1)),0,0],
[0,0,0,0.5*(e4+abs(e4)),0],
[0,0,0,0,0.5*(e5+abs(e5))]]$
(C78) be2:matrix([0.5*(e1-abs(e1)),0,0,0,0],
[0,0.5*(e1-abs(e1)),0,0,0],
[0,0,0.5*(e1-abs(e1)),0,0],
[0,0,0,0.5*(e4-abs(e4)),0],
[0,0,0,0,0.5*(e5-abs(e5))]]$
(C79) a:q1/(sqrt(2)*c)$
(C80) c1:0.5*rqrq$
(C81) c2:c*c/gm1$
(C82) br:matrix([axt,ayt,azt,a,a],
[q2*axt,q2*ayt-q1*azt,q2*azt+q1*ayt,a*(q2+c*axt),a*(q2-c*axt)],
[q3*axt+q1*azt,q3*ayt,q3*azt-q1*axt,a*(q3+c*ayt),a*(q3-c*ayt)],
[q4*axt-q1*ayt,q4*ayt+q1*axt,q4*azt,a*(q4+c*azt),a*(q4-c*azt)],
[c1*axt+q1*(q3*azt-q4*ayt),c1*ayt+q1*(q4*axt-q2*azt),
c1*azt+q1*(q2*ayt-q3*axt),a*(c1+c2+c*tt),a*(c1+c2-c*tt)]])$
(C83) phi:0.5*gm1*rqrq$
(C84) c2:c*c$
(C85) b:1/(sqrt(2)*rc)$
(C86) c1:1-phi/c2$
(C87) c3:gm1/c2$
(C88) bl:matrix([axt*c1+q6*(q4*ayt-q3*azt),axt*q2*c3,axt*q3*c3+azt
*q6,
axt*q4*c3-ayt*q6,-axt*c3],
[ayt*c1+q6*(q2*azt-q4*axt),ayt*q2*c3-azt*q6,ayt*q3*c3,
ayt*q4*c3+axt*q6,-ayt*c3],
[azt*c1+q6*(q3*axt-q2*ayt),azt*q2*c3+ayt*q6,azt*q3*c3-axt*q6,
azt*q4*c3,-azt*c3],
[b*(phi-c*tt),b*(c*axt-q2*gm1),b*(c*ayt-q3*gm1),b*(c*azt-q4*gm1),
b*gm1],
[b*(phi+c*tt),-b*(c*axt+q2*gm1),-b*(c*ayt+q3*gm1),-b*(c*azt+q4*gm1
)],
b*gm1]))$
(C89) sp:bl.dq$
(C90) sp2:be1.sp$
(C91) sp:bl.dq$
(C92) sm2:be2.sp$
(C93) h:br.sm2-br.sp2$
(C94) t1:(qm[2]*ax+qm[3]*ay+qm[4]*az)/qm[1]$
(C95) h[1]:qm[1]*t1+h[1]$
(C96) h[2]:qm[2]*t1+ax*qm[6]+h[2]$
(C97) h[3]:qm[3]*t1+ay*qm[6]+h[3]$
(C98) h[4]:qm[4]*t1+az*qm[6]+h[4]$
(C99) h[5]:(qm[5]+qm[6])*t1+h[5]$
(C100) t1:(qp[2]*ax+qp[3]*ay+qp[4]*az)/qp[1]$
(C101) hhatijk[1]:0.5*(qp[1]*t1+h[1])$
(C102) hhatijk[2]:0.5*(qp[2]*t1+ax*qp[6]+h[2])$
(C103) hhatijk[3]:0.5*(qp[3]*t1+ay*qp[6]+h[3])$
(C104) hhatijk[4]:0.5*(qp[4]*t1+az*qp[6]+h[4])$

```

HFLUX2

```
(C105) hhatijk[5]:0.5*((qp[5]+qp[6])*t1+h[5])$
(C106) diff:hijk+m.hhatijk$
(C107) diff:ratexpand(diff);
```

```
(D107)
```

```
[ 0 ]
[  ]
[ 0 ]
[  ]
[ 0 ]
[  ]
[ 0 ]
[  ]
[ 0 ]
```

```
(C108) closefile(hflux2)$
```

```

(C3) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.5*(e5+sign*abs(e5))$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:cgg2$
(C34) dlq1:-ev1*q6$
(C35) dlq2:xix*q6$
(C36) dlq3:xiy*q6$
(C37) dlq4:xiz*q6$
(C38) dlq5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gmlq6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$

```

(C50) dcq5:drcq5*q6\$
 (C51) depq1:0.5*gmlq6*rqrq*q6\$
 (C52) depq2:-q2*gmlq6\$
 (C53) depq3:-q3*gmlq6\$
 (C54) depq4:-q4*gmlq6\$
 (C55) depq5:gam\$
 (C56) dttq1:-tt*q6\$
 (C57) dttq2:axt*q6\$
 (C58) dttq3:ayt*q6\$
 (C59) dttq4:azt*q6\$
 (C60) dttq5:0.0\$
 (C61) d4q1:sada*(dttq1+dcq1)\$
 (C62) d4q2:sada*(dttq2+dcq2)\$
 (C63) d4q3:sada*(dttq3+dcq3)\$
 (C64) d4q4:sada*(dttq4+dcq4)\$
 (C65) d4q5:sada*dcq5\$
 (C66) d5q1:sada*(dttq1-dcq1)\$
 (C67) d5q2:sada*(dttq2-dcq2)\$
 (C68) d5q3:sada*(dttq3-dcq3)\$
 (C69) d5q4:sada*(dttq4-dcq4)\$
 (C70) d5q5:-d4q5\$
 (C71) a411:ev4+q1*d4q1\$
 (C72) a511:ev5+q1*d5q1\$
 (C73) ap1[1,1]:cg2*a411+cg3*a511\$
 (C74) ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C75) ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C76) ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C77) ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C78) rcaxt:rc*axt\$
 (C79) ev4ax:ev4*axt\$
 (C80) ev5ax:ev5*axt\$
 (C81) coe1:q2+rcaxt\$
 (C82) coe:q2-rcaxt\$
 (C83) a121:q2*d1q1\$
 (C84) a421:ev4ax*drcq1+coe1*d4q1\$
 (C85) a521:-ev5ax*drcq1+coe*d5q1\$
 (C86) ap1[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C87) a122:q2*d1q2+ev1\$
 (C88) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C89) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C90) ap1[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C91) a123:q2*d1q3\$
 (C92) a423:ev4ax*drcq3+coe1*d4q3\$
 (C93) a523:-ev5ax*drcq3+coe*d5q3\$
 (C94) ap1[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C95) a124:q2*d1q4\$
 (C96) a424:ev4ax*drcq4+coe1*d4q4\$
 (C97) a524:-ev5ax*drcq4+coe*d5q4\$
 (C98) ap1[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C99) a125:q2*d1q5\$
 (C100) a425:ev4ax*drcq5+coe1*d4q5\$

(C101) a525:-ev5ax*drcq5+coe*d5q5\$
(C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525\$
(C103) rcayt:rc*ayt\$
(C104) ev4ay:ev4*ayt\$
(C105) ev5ay:ev5*ayt\$
(C106) coe1:q3+rcayt\$
(C107) coe:q3-rcayt\$
(C108) a131:q3*d1q1\$
(C109) a431:ev4ay*drcq1+coe1*d4q1\$
(C110) a531:-ev5ay*drcq1+coe*d5q1\$
(C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531\$
(C112) a132:q3*d1q2\$
(C113) a432:ev4ay*drcq2+coe1*d4q2\$
(C114) a532:-ev5ay*drcq2+coe*d5q2\$
(C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532\$
(C116) a133:q3*d1q3+ev1\$
(C117) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
(C118) a533:ev5-ev5ay*drcq3+coe*d5q3\$
(C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533\$
(C120) a134:q3*d1q4\$
(C121) a434:ev4ay*drcq4+coe1*d4q4\$
(C122) a534:-ev5ay*drcq4+coe*d5q4\$
(C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534\$
(C124) a135:q3*d1q5\$
(C125) a435:ev4ay*drcq5+coe1*d4q5\$
(C126) a535:-ev5ay*drcq5+coe*d5q5\$
(C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535\$
(C128) rcazt:rc*azt\$
(C129) ev4az:ev4*azt\$
(C130) ev5az:ev5*azt\$
(C131) coe1:q4+rcazt\$
(C132) coe:q4-rcazt\$
(C133) a141:q4*d1q1\$
(C134) a441:ev4az*drcq1+coe1*d4q1\$
(C135) a541:-ev5az*drcq1+coe*d5q1\$
(C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541\$
(C137) a142:q4*d1q2\$
(C138) a442:ev4az*drcq2+coe1*d4q2\$
(C139) a542:-ev5az*drcq2+coe*d5q2\$
(C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542\$
(C141) a143:q4*d1q3\$
(C142) a443:ev4az*drcq3+coe1*d4q3\$
(C143) a543:-ev5az*drcq3+coe*d5q3\$
(C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543\$
(C145) a144:q4*d1q4+ev1\$
(C146) a444:ev4+ev4az*drcq4+coe1*d4q4\$
(C147) a544:ev5-ev5az*drcq4+coe*d5q4\$
(C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544\$
(C149) a145:q4*d1q5\$
(C150) a445:ev4az*drcq5+coe1*d4q5\$
(C151) a545:-ev5az*drcq5+coe*d5q5\$

(C152) $ap1[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C153) $rctt:rc*tt\$$
 (C154) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C155) $rt:rc*dttq1+tt*drcq1\$$
 (C156) $a151:2*coe*d1q1\$$
 (C157) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C158) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C159) $ap1[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C160) $rt:rc*dttq2+tt*drcq2\$$
 (C161) $a152:coe*d1q2-d1q1*q2\$$
 (C162) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C163) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C164) $ap1[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C165) $rt:rc*dttq3+tt*drcq3\$$
 (C166) $a153:coe*d1q3-d1q1*q3\$$
 (C167) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C168) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C169) $ap1[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C170) $rt:rc*dttq4+tt*drcq4\$$
 (C171) $a154:coe*d1q4-d1q1*q4\$$
 (C172) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C173) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C174) $ap1[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C175) $rt:tt*drcq5\$$
 (C176) $a155:coe*d1q5\$$
 (C177) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$
 (C178) $a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$$
 (C179) $ap1[5,5]:cg1*a155+cg2*a455+cg3*a555\$$
 (C180) $q1:q1\$$
 (C181) $q2:q2\$$
 (C182) $q3:q3\$$
 (C183) $q4:-q4\$$
 (C184) $q5:q5\$$
 (C185) $sign:1\$$
 (C186) $cg1:(gam-1)/gam\$$
 (C187) $cg2:1/(2*gam)\$$
 (C188) $sada:sqrt(xix**2+xiz**2+xiz**2)\$$
 (C189) $axt:xix/sada\$$
 (C190) $ayt:xiz/sada\$$
 (C191) $azt:xiz/sada\$$
 (C192) $rqrq:q2**2+q3**2+q4**2\$$
 (C193) $q6:1/q1\$$
 (C194) $pr:(gam-1)*(q5-0.5*rqrq*q6)\$$
 (C195) $prgam:pr*gam\$$
 (C196) $pp:q5+pr\$$
 (C197) $c:sqrt(prgam*q6)\$$
 (C198) $tt:(q2*axt+q3*ayt+q4*azt)*q6\$$
 (C199) $rc:q1*c\$$
 (C200) $csad:c*sada\$$
 (C201) $e1:tt*sada\$$
 (C202) $e4:e1+csad\$$

```

(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.5*(e5+sign*abs(e5))$
(C207) cg1:cgq1$
(C208) cg2:cgq2$
(C209) cg3:cgq2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gmlq6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gmlq6*rqrq*q6$
(C228) depq2:-q2*gmlq6$
(C229) depq3:-q3*gmlq6$
(C230) depq4:-q4*gmlq6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) ap2[1,1]:cg2*a411+cg3*a511$
(C251) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$

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(C253) $ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C254) $ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C255) $rcaxt:rc*axt\$$
 (C256) $ev4ax:ev4*axt\$$
 (C257) $ev5ax:ev5*axt\$$
 (C258) $coe1:q2+rcaxt\$$
 (C259) $coe:q2-rcaxt\$$
 (C260) $a121:q2*d1q1\$$
 (C261) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C262) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C263) $ap2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C264) $a122:q2*d1q2+ev1\$$
 (C265) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C266) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C267) $ap2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C268) $a123:q2*d1q3\$$
 (C269) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C270) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C271) $ap2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C272) $a124:q2*d1q4\$$
 (C273) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C274) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C275) $ap2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C276) $a125:q2*d1q5\$$
 (C277) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C278) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C279) $ap2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C280) $rcayt:rc*ayt\$$
 (C281) $ev4ay:ev4*ayt\$$
 (C282) $ev5ay:ev5*ayt\$$
 (C283) $coe1:q3+rcayt\$$
 (C284) $coe:q3-rcayt\$$
 (C285) $a131:q3*d1q1\$$
 (C286) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C287) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C288) $ap2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C289) $a132:q3*d1q2\$$
 (C290) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C291) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C292) $ap2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C293) $a133:q3*d1q3+ev1\$$
 (C294) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C295) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C296) $ap2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C297) $a134:q3*d1q4\$$
 (C298) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C299) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C300) $ap2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C301) $a135:q3*d1q5\$$
 (C302) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C303) $a535:-ev5ay*drcq5+coe*d5q5\$$

(C304) ap2[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C305) rcazt:rc*azt\$
 (C306) ev4az:ev4*azt\$
 (C307) ev5az:ev5*azt\$
 (C308) coe1:q4+rcazt\$
 (C309) coe:q4-rcazt\$
 (C310) a141:q4*d1q1\$
 (C311) a441:ev4az*drcq1+coe1*d4q1\$
 (C312) a541:-ev5az*drcq1+coe*d5q1\$
 (C313) ap2[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C314) a142:q4*d1q2\$
 (C315) a442:ev4az*drcq2+coe1*d4q2\$
 (C316) a542:-ev5az*drcq2+coe*d5q2\$
 (C317) ap2[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C318) a143:q4*d1q3\$
 (C319) a443:ev4az*drcq3+coe1*d4q3\$
 (C320) a543:-ev5az*drcq3+coe*d5q3\$
 (C321) ap2[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C322) a144:q4*d1q4+ev1\$
 (C323) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C324) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C325) ap2[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C326) a145:q4*d1q5\$
 (C327) a445:ev4az*drcq5+coe1*d4q5\$
 (C328) a545:-ev5az*drcq5+coe*d5q5\$
 (C329) ap2[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C330) rctt:rc*tt\$
 (C331) coe:0.5*(q2**2+q3**2+q4**2)*q6\$
 (C332) rt:rc*dttq1+tt*drcq1\$
 (C333) a151:2*coe*d1q1\$
 (C334) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$
 (C335) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$
 (C336) ap2[5,1]:cg1*a151+cg2*a451+cg3*a551\$
 (C337) rt:rc*dttq2+tt*drcq2\$
 (C338) a152:coe*d1q2-d1q1*q2\$
 (C339) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$
 (C340) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$
 (C341) ap2[5,2]:cg1*a152+cg2*a452+cg3*a552\$
 (C342) rt:rc*dttq3+tt*drcq3\$
 (C343) a153:coe*d1q3-d1q1*q3\$
 (C344) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$
 (C345) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$
 (C346) ap2[5,3]:cg1*a153+cg2*a453+cg3*a553\$
 (C347) rt:rc*dttq4+tt*drcq4\$
 (C348) a154:coe*d1q4-d1q1*q4\$
 (C349) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$
 (C350) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$
 (C351) ap2[5,4]:cg1*a154+cg2*a454+cg3*a554\$
 (C352) rt:tt*drcq5\$
 (C353) a155:coe*d1q5\$
 (C354) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$

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(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:ap1.m-m.ap2$
(C358) diff:ratexpand(diff);
```

(D358)

```
[ 0  0  0  0  0 ]
[ 0  0  0  0  0 ]
[ 0  0  0  0  0 ]
[ 0  0  0  0  0 ]
[ 0  0  0  0  0 ]
[ 0  0  0  0  0 ]
```

```
(C359) closefile(Apsup)$
```

■

```

(C3) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.0$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:0.0$
(C34) d1q1:-ev1*q6$
(C35) d1q2:xix*q6$
(C36) d1q3:xiy*q6$
(C37) d1q4:xiz*q6$
(C38) d1q5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gmlq6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$

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(C50) dcq5:drcq5*q6\$
 (C51) depq1:0.5*gmlq6*rqrq*q6\$
 (C52) depq2:-q2*gmlq6\$
 (C53) depq3:-q3*gmlq6\$
 (C54) depq4:-q4*gmlq6\$
 (C55) depq5:gam\$
 (C56) dttq1:-tt*q6\$
 (C57) dttq2:axt*q6\$
 (C58) dttq3:ayt*q6\$
 (C59) dttq4:azt*q6\$
 (C60) dttq5:0.0\$
 (C61) d4q1:sada*(dttq1+dcq1)\$
 (C62) d4q2:sada*(dttq2+dcq2)\$
 (C63) d4q3:sada*(dttq3+dcq3)\$
 (C64) d4q4:sada*(dttq4+dcq4)\$
 (C65) d4q5:sada*dcq5\$
 (C66) d5q1:sada*(dttq1-dcq1)\$
 (C67) d5q2:sada*(dttq2-dcq2)\$
 (C68) d5q3:sada*(dttq3-dcq3)\$
 (C69) d5q4:sada*(dttq4-dcq4)\$
 (C70) d5q5:-d4q5\$
 (C71) a411:ev4+q1*d4q1\$
 (C72) a511:ev5+q1*d5q1\$
 (C73) ap1[1,1]:cg2*a411+cg3*a511\$
 (C74) ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C75) ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C76) ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C77) ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C78) rcaxt:rc*axt\$
 (C79) ev4ax:ev4*axt\$
 (C80) ev5ax:ev5*axt\$
 (C81) coe1:q2+rcaxt\$
 (C82) coe:q2-rcaxt\$
 (C83) a121:q2*d1q1\$
 (C84) a421:ev4ax*drcq1+coe1*d4q1\$
 (C85) a521:-ev5ax*drcq1+coe*d5q1\$
 (C86) ap1[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C87) a122:q2*d1q2+ev1\$
 (C88) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C89) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C90) ap1[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C91) a123:q2*d1q3\$
 (C92) a423:ev4ax*drcq3+coe1*d4q3\$
 (C93) a523:-ev5ax*drcq3+coe*d5q3\$
 (C94) ap1[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C95) a124:q2*d1q4\$
 (C96) a424:ev4ax*drcq4+coe1*d4q4\$
 (C97) a524:-ev5ax*drcq4+coe*d5q4\$
 (C98) ap1[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C99) a125:q2*d1q5\$
 (C100) a425:ev4ax*drcq5+coe1*d4q5\$

(C101) a525:-ev5ax*drcq5+coe*d5q5\$
 (C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C103) rcayt:rc*ayt\$
 (C104) ev4ay:ev4*ayt\$
 (C105) ev5ay:ev5*ayt\$
 (C106) coe1:q3+rcayt\$
 (C107) coe:q3-rcayt\$
 (C108) a131:q3*d1q1\$
 (C109) a431:ev4ay*drcq1+coe1*d4q1\$
 (C110) a531:-ev5ay*drcq1+coe*d5q1\$
 (C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C112) a132:q3*d1q2\$
 (C113) a432:ev4ay*drcq2+coe1*d4q2\$
 (C114) a532:-ev5ay*drcq2+coe*d5q2\$
 (C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C116) a133:q3*d1q3+ev1\$
 (C117) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C118) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C120) a134:q3*d1q4\$
 (C121) a434:ev4ay*drcq4+coe1*d4q4\$
 (C122) a534:-ev5ay*drcq4+coe*d5q4\$
 (C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C124) a135:q3*d1q5\$
 (C125) a435:ev4ay*drcq5+coe1*d4q5\$
 (C126) a535:-ev5ay*drcq5+coe*d5q5\$
 (C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C128) rcazt:rc*azt\$
 (C129) ev4az:ev4*azt\$
 (C130) ev5az:ev5*azt\$
 (C131) coe1:q4+rcazt\$
 (C132) coe:q4-rcazt\$
 (C133) a141:q4*d1q1\$
 (C134) a441:ev4az*drcq1+coe1*d4q1\$
 (C135) a541:-ev5az*drcq1+coe*d5q1\$
 (C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C137) a142:q4*d1q2\$
 (C138) a442:ev4az*drcq2+coe1*d4q2\$
 (C139) a542:-ev5az*drcq2+coe*d5q2\$
 (C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C141) a143:q4*d1q3\$
 (C142) a443:ev4az*drcq3+coe1*d4q3\$
 (C143) a543:-ev5az*drcq3+coe*d5q3\$
 (C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C145) a144:q4*d1q4+ev1\$
 (C146) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C147) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C149) a145:q4*d1q5\$
 (C150) a445:ev4az*drcq5+coe1*d4q5\$
 (C151) a545:-ev5az*drcq5+coe*d5q5\$

(C152) $ap1[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C153) $rctt:rc*tt\$$
 (C154) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C155) $rt:rc*dttq1+tt*drcq1\$$
 (C156) $a151:2*coe*d1q1\$$
 (C157) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C158) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C159) $ap1[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C160) $rt:rc*dttq2+tt*drcq2\$$
 (C161) $a152:coe*d1q2-d1q1*q2\$$
 (C162) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C163) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C164) $ap1[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C165) $rt:rc*dttq3+tt*drcq3\$$
 (C166) $a153:coe*d1q3-d1q1*q3\$$
 (C167) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C168) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C169) $ap1[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C170) $rt:rc*dttq4+tt*drcq4\$$
 (C171) $a154:coe*d1q4-d1q1*q4\$$
 (C172) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C173) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C174) $ap1[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C175) $rt:tt*drcq5\$$
 (C176) $a155:coe*d1q5\$$
 (C177) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$
 (C178) $a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$$
 (C179) $ap1[5,5]:cg1*a155+cg2*a455+cg3*a555\$$
 (C180) $q1:q1\$$
 (C181) $q2:q2\$$
 (C182) $q3:q3\$$
 (C183) $q4:-q4\$$
 (C184) $q5:q5\$$
 (C185) $sign:1\$$
 (C186) $cg1:(gam-1)/gam\$$
 (C187) $cg2:1/(2*gam)\$$
 (C188) $sada:sqrt(xix**2+xiy**2+xiz**2)\$$
 (C189) $axt:xix/sada\$$
 (C190) $ayt:xiy/sada\$$
 (C191) $azt:xiz/sada\$$
 (C192) $rqrq:q2**2+q3**2+q4**2\$$
 (C193) $q6:1/q1\$$
 (C194) $pr:(gam-1)*(q5-0.5*rqrq*q6)\$$
 (C195) $prgam:pr*gam\$$
 (C196) $pp:q5+pr\$$
 (C197) $c:sqrt(prgam*q6)\$$
 (C198) $tt:(q2*axt+q3*ayt+q4*azt)*q6\$$
 (C199) $rc:q1*c\$$
 (C200) $csad:c*sada\$$
 (C201) $e1:tt*sada\$$
 (C202) $e4:e1+csad\$$

(C203) e5:e1-csad\$
 (C204) ev1:0.5*(e1+sign*abs(e1))\$
 (C205) ev4:0.5*(e4+sign*abs(e4))\$
 (C206) ev5:0.0\$
 (C207) cg1:cg1\$
 (C208) cg2:cg2\$
 (C209) cg3:0.0\$
 (C210) dlq1:-ev1*q6\$
 (C211) dlq2:xix*q6\$
 (C212) dlq3:xiy*q6\$
 (C213) dlq4:xiz*q6\$
 (C214) dlq5:0.0\$
 (C215) coe:gam*(gam-1)/(2*rc)\$
 (C216) gmlq6:(gam-1)*q6\$
 (C217) drcq1:coe*q5\$
 (C218) drcq2:-coe*q2\$
 (C219) drcq3:-coe*q3\$
 (C220) drcq4:-coe*q4\$
 (C221) drcq5:coe*q1\$
 (C222) dcq1:(drcq1-c)*q6\$
 (C223) dcq2:drcq2*q6\$
 (C224) dcq3:drcq3*q6\$
 (C225) dcq4:drcq4*q6\$
 (C226) dcq5:drcq5*q6\$
 (C227) depq1:0.5*gmlq6*rqrq*q6\$
 (C228) depq2:-q2*gmlq6\$
 (C229) depq3:-q3*gmlq6\$
 (C230) depq4:-q4*gmlq6\$
 (C231) depq5:gam\$
 (C232) dttq1:-tt*q6\$
 (C233) dttq2:axt*q6\$
 (C234) dttq3:ayt*q6\$
 (C235) dttq4:azt*q6\$
 (C236) dttq5:0.0\$
 (C237) d4q1:sada*(dttq1+dcq1)\$
 (C238) d4q2:sada*(dttq2+dcq2)\$
 (C239) d4q3:sada*(dttq3+dcq3)\$
 (C240) d4q4:sada*(dttq4+dcq4)\$
 (C241) d4q5:sada*dcq5\$
 (C242) d5q1:sada*(dttq1-dcq1)\$
 (C243) d5q2:sada*(dttq2-dcq2)\$
 (C244) d5q3:sada*(dttq3-dcq3)\$
 (C245) d5q4:sada*(dttq4-dcq4)\$
 (C246) d5q5:-d4q5\$
 (C247) a411:ev4+q1*d4q1\$
 (C248) a511:ev5+q1*d5q1\$
 (C249) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
 [0,0,0,0,0])\$
 (C250) ap2[1,1]:cg2*a411+cg3*a511\$
 (C251) ap2[1,2]:(cg1*dlq2+cg2*d4q2+cg3*d5q2)*q1\$
 (C252) ap2[1,3]:(cg1*dlq3+cg2*d4q3+cg3*d5q3)*q1\$

(C253) $ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C254) $ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C255) $rcaxt:rc*axt\$$
 (C256) $ev4ax:ev4*axt\$$
 (C257) $ev5ax:ev5*axt\$$
 (C258) $coe1:q2+rcaxt\$$
 (C259) $coe:q2-rcaxt\$$
 (C260) $a121:q2*d1q1\$$
 (C261) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C262) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C263) $ap2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C264) $a122:q2*d1q2+ev1\$$
 (C265) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C266) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C267) $ap2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C268) $a123:q2*d1q3\$$
 (C269) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C270) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C271) $ap2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C272) $a124:q2*d1q4\$$
 (C273) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C274) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C275) $ap2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C276) $a125:q2*d1q5\$$
 (C277) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C278) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C279) $ap2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C280) $rcayt:rc*ayt\$$
 (C281) $ev4ay:ev4*ayt\$$
 (C282) $ev5ay:ev5*ayt\$$
 (C283) $coe1:q3+rcayt\$$
 (C284) $coe:q3-rcayt\$$
 (C285) $a131:q3*d1q1\$$
 (C286) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C287) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C288) $ap2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C289) $a132:q3*d1q2\$$
 (C290) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C291) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C292) $ap2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C293) $a133:q3*d1q3+ev1\$$
 (C294) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C295) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C296) $ap2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C297) $a134:q3*d1q4\$$
 (C298) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C299) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C300) $ap2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C301) $a135:q3*d1q5\$$
 (C302) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C303) $a535:-ev5ay*drcq5+coe*d5q5\$$

(C304) $ap2[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C305) $rcazt:rc*azt\$$
 (C306) $ev4az:ev4*azt\$$
 (C307) $ev5az:ev5*azt\$$
 (C308) $coe1:q4+rcazt\$$
 (C309) $coe:q4-rcazt\$$
 (C310) $a141:q4*d1q1\$$
 (C311) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C312) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C313) $ap2[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C314) $a142:q4*d1q2\$$
 (C315) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C316) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C317) $ap2[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C318) $a143:q4*d1q3\$$
 (C319) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C320) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C321) $ap2[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C322) $a144:q4*d1q4+ev1\$$
 (C323) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C324) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C325) $ap2[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C326) $a145:q4*d1q5\$$
 (C327) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C328) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C329) $ap2[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C330) $rctt:rc*tt\$$
 (C331) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C332) $rt:rc*dttq1+tt*drcq1\$$
 (C333) $a151:2*coe*d1q1\$$
 (C334) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C335) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C336) $ap2[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C337) $rt:rc*dttq2+tt*drcq2\$$
 (C338) $a152:coe*d1q2-d1q1*q2\$$
 (C339) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C340) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C341) $ap2[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C342) $rt:rc*dttq3+tt*drcq3\$$
 (C343) $a153:coe*d1q3-d1q1*q3\$$
 (C344) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C345) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C346) $ap2[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C347) $rt:rc*dttq4+tt*drcq4\$$
 (C348) $a154:coe*d1q4-d1q1*q4\$$
 (C349) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C350) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C351) $ap2[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C352) $rt:tt*drcq5\$$
 (C353) $a155:coe*d1q5\$$
 (C354) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$

APSUB

```
(C355) a555:ev5*(depg5-rt)+(pp-rctt)*d5q5$
(C356) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:apl.m-m.ap2$
(C358) diff:ratexpand(diff);
```

```
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
```

(D358)

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(C359) closefile(Apsub)$
```

■

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(C3) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) xiy:0.0$
(C11) xiz:0.0$
(C12) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C13) axt:xix/sada$
(C14) ayt:xiy/sada$
(C15) azt:xiz/sada$
(C16) rqrq:q2**2+q3**2+q4**2$
(C17) q6:1/q1$
(C18) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C19) prgam:pr*gam$
(C20) pp:q5+pr$
(C21) c:sqrt(prgam*q6)$
(C22) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C23) rc:q1*c$
(C24) csad:c*sada$
(C25) e1:tt*sada$
(C26) e4:e1+csad$
(C27) e5:e1-csad$
(C28) ev1:0.5*(e1+sign*abs(e1))$
(C29) ev4:0.5*(e4+sign*abs(e4))$
(C30) ev5:0.0$
(C31) cg1:cgg1$
(C32) cg2:cgg2$
(C33) cg3:0.0$
(C34) dlq1:-ev1*q6$
(C35) dlq2:xix*q6$
(C36) dlq3:xiy*q6$
(C37) dlq4:xiz*q6$
(C38) dlq5:0.0$
(C39) coe:gam*(gam-1)/(2*rc)$
(C40) gmlq6:(gam-1)*q6$
(C41) drcq1:coe*q5$
(C42) drcq2:-coe*q2$
(C43) drcq3:-coe*q3$
(C44) drcq4:-coe*q4$
(C45) drcq5:coe*q1$
(C46) dcq1:(drcq1-c)*q6$
(C47) dcq2:drcq2*q6$
(C48) dcq3:drcq3*q6$
(C49) dcq4:drcq4*q6$

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(C50) $dcq5:drcq5*q6\$$
 (C51) $depq1:0.5*gm1q6*rqrq*q6\$$
 (C52) $depq2:-q2*gm1q6\$$
 (C53) $depq3:-q3*gm1q6\$$
 (C54) $depq4:-q4*gm1q6\$$
 (C55) $depq5:gam\$$
 (C56) $dtq1:-tt*q6\$$
 (C57) $dtq2:axt*q6\$$
 (C58) $dtq3:ayt*q6\$$
 (C59) $dtq4:azt*q6\$$
 (C60) $dtq5:0.0\$$
 (C61) $d4q1:sada*(dtq1+dcq1)\$$
 (C62) $d4q2:sada*(dtq2+dcq2)\$$
 (C63) $d4q3:sada*(dtq3+dcq3)\$$
 (C64) $d4q4:sada*(dtq4+dcq4)\$$
 (C65) $d4q5:sada*dcq5\$$
 (C66) $d5q1:sada*(dtq1-dcq1)\$$
 (C67) $d5q2:sada*(dtq2-dcq2)\$$
 (C68) $d5q3:sada*(dtq3-dcq3)\$$
 (C69) $d5q4:sada*(dtq4-dcq4)\$$
 (C70) $d5q5:-d4q5\$$
 (C71) $a411:ev4+q1*d4q1\$$
 (C72) $a511:ev5+q1*d5q1\$$
 (C73) $ap1[1,1]:cg2*a411+cg3*a511\$$
 (C74) $ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$$
 (C75) $ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$$
 (C76) $ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C77) $ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C78) $rcaxt:rc*axt\$$
 (C79) $ev4ax:ev4*axt\$$
 (C80) $ev5ax:ev5*axt\$$
 (C81) $coe1:q2+rcaxt\$$
 (C82) $coe:q2-rcaxt\$$
 (C83) $a121:q2*d1q1\$$
 (C84) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C85) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C86) $ap1[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C87) $a122:q2*d1q2+ev1\$$
 (C88) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C89) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C90) $ap1[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C91) $a123:q2*d1q3\$$
 (C92) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C93) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C94) $ap1[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C95) $a124:q2*d1q4\$$
 (C96) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C97) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C98) $ap1[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C99) $a125:q2*d1q5\$$
 (C100) $a425:ev4ax*drcq5+coe1*d4q5\$$

(C101) a525:-ev5ax*drcq5+coe*d5q5\$
 (C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C103) rcayt:rc*ayt\$
 (C104) ev4ay:ev4*ayt\$
 (C105) ev5ay:ev5*ayt\$
 (C106) coe1:q3+rcayt\$
 (C107) coe:q3-rcayt\$
 (C108) a131:q3*d1q1\$
 (C109) a431:ev4ay*drcq1+coe1*d4q1\$
 (C110) a531:-ev5ay*drcq1+coe*d5q1\$
 (C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C112) a132:q3*d1q2\$
 (C113) a432:ev4ay*drcq2+coe1*d4q2\$
 (C114) a532:-ev5ay*drcq2+coe*d5q2\$
 (C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C116) a133:q3*d1q3+ev1\$
 (C117) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C118) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C120) a134:q3*d1q4\$
 (C121) a434:ev4ay*drcq4+coe1*d4q4\$
 (C122) a534:-ev5ay*drcq4+coe*d5q4\$
 (C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C124) a135:q3*d1q5\$
 (C125) a435:ev4ay*drcq5+coe1*d4q5\$
 (C126) a535:-ev5ay*drcq5+coe*d5q5\$
 (C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C128) rcazt:rc*azt\$
 (C129) ev4az:ev4*azt\$
 (C130) ev5az:ev5*azt\$
 (C131) coe1:q4+rcazt\$
 (C132) coe:q4-rcazt\$
 (C133) a141:q4*d1q1\$
 (C134) a441:ev4az*drcq1+coe1*d4q1\$
 (C135) a541:-ev5az*drcq1+coe*d5q1\$
 (C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C137) a142:q4*d1q2\$
 (C138) a442:ev4az*drcq2+coe1*d4q2\$
 (C139) a542:-ev5az*drcq2+coe*d5q2\$
 (C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C141) a143:q4*d1q3\$
 (C142) a443:ev4az*drcq3+coe1*d4q3\$
 (C143) a543:-ev5az*drcq3+coe*d5q3\$
 (C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C145) a144:q4*d1q4+ev1\$
 (C146) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C147) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C149) a145:q4*d1q5\$
 (C150) a445:ev4az*drcq5+coe1*d4q5\$
 (C151) a545:-ev5az*drcq5+coe*d5q5\$

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(C152) ap1[4,5]:cg1*a145+cg2*a445+cg3*a545$
(C153) rctt:rc*tt$
(C154) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C155) rt:rc*dttq1+tt*drcq1$
(C156) a151:2*coe*d1q1$
(C157) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C158) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C159) ap1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C160) rt:rc*dttq2+tt*drcq2$
(C161) a152:coe*d1q2-d1q1*q2$
(C162) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C163) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C164) ap1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C165) rt:rc*dttq3+tt*drcq3$
(C166) a153:coe*d1q3-d1q1*q3$
(C167) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C168) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C169) ap1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C170) rt:rc*dttq4+tt*drcq4$
(C171) a154:coe*d1q4-d1q1*q4$
(C172) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C173) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C174) ap1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C175) rt:tt*drcq5$
(C176) a155:coe*d1q5$
(C177) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C178) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C179) ap1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C180) q1:q1$
(C181) q2:q2$
(C182) q3:q3$
(C183) q4:-q4$
(C184) q5:q5$
(C185) sign:1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C189) axt:xix/sada$
(C190) ayt:xiy/sada$
(C191) azt:xiz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$

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(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.0$
(C207) cg1:cg1$
(C208) cg2:cg2$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gmlq6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gmlq6*rqrq*q6$
(C228) depq2:-q2*gmlq6$
(C229) depq3:-q3*gmlq6$
(C230) depq4:-q4*gmlq6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) ap2[1,1]:cg2*a411+cg3*a511$
(C251) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$

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(C253) $ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C254) $ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C255) $rcaxt:rc*axt\$$
 (C256) $ev4ax:ev4*axt\$$
 (C257) $ev5ax:ev5*axt\$$
 (C258) $coe1:q2+rcaxt\$$
 (C259) $coe:q2-rcaxt\$$
 (C260) $a121:q2*d1q1\$$
 (C261) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C262) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C263) $ap2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C264) $a122:q2*d1q2+ev1\$$
 (C265) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C266) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C267) $ap2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C268) $a123:q2*d1q3\$$
 (C269) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C270) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C271) $ap2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C272) $a124:q2*d1q4\$$
 (C273) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C274) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C275) $ap2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C276) $a125:q2*d1q5\$$
 (C277) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C278) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C279) $ap2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C280) $rcayt:rc*ayt\$$
 (C281) $ev4ay:ev4*ayt\$$
 (C282) $ev5ay:ev5*ayt\$$
 (C283) $coe1:q3+rcayt\$$
 (C284) $coe:q3-rcayt\$$
 (C285) $a131:q3*d1q1\$$
 (C286) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C287) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C288) $ap2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C289) $a132:q3*d1q2\$$
 (C290) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C291) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C292) $ap2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C293) $a133:q3*d1q3+ev1\$$
 (C294) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C295) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C296) $ap2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C297) $a134:q3*d1q4\$$
 (C298) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C299) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C300) $ap2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C301) $a135:q3*d1q5\$$
 (C302) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C303) $a535:-ev5ay*drcq5+coe*d5q5\$$

(C304) $ap2[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C305) $rcazt:rc*azt\$$
 (C306) $ev4az:ev4*azt\$$
 (C307) $ev5az:ev5*azt\$$
 (C308) $coe1:q4+rcazt\$$
 (C309) $coe:q4-rcazt\$$
 (C310) $a141:q4*d1q1\$$
 (C311) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C312) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C313) $ap2[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C314) $a142:q4*d1q2\$$
 (C315) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C316) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C317) $ap2[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C318) $a143:q4*d1q3\$$
 (C319) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C320) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C321) $ap2[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C322) $a144:q4*d1q4+ev1\$$
 (C323) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C324) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C325) $ap2[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C326) $a145:q4*d1q5\$$
 (C327) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C328) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C329) $ap2[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C330) $rctt:rc*tt\$$
 (C331) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C332) $rt:rc*dttq1+tt*drcq1\$$
 (C333) $a151:2*coe*d1q1\$$
 (C334) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C335) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C336) $ap2[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C337) $rt:rc*dttq2+tt*drcq2\$$
 (C338) $a152:coe*d1q2-d1q1*q2\$$
 (C339) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C340) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C341) $ap2[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C342) $rt:rc*dttq3+tt*drcq3\$$
 (C343) $a153:coe*d1q3-d1q1*q3\$$
 (C344) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C345) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C346) $ap2[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C347) $rt:rc*dttq4+tt*drcq4\$$
 (C348) $a154:coe*d1q4-d1q1*q4\$$
 (C349) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C350) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C351) $ap2[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C352) $rt:tt*drcq5\$$
 (C353) $a155:coe*d1q5\$$
 (C354) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$

APSUB

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:ap1.m-m.ap2$
(C358) diff:ratexpand(diff);
```

```
[ 0  0  0  0  0 ]
[      ]
[ 0  0  0  0  0 ]
[      ]
[ 0  0  0  0  0 ]
[      ]
[ 0  0  0  0  0 ]
[      ]
[ 0  0  0  0  0 ]
```

```
(D358)
```

```
(C359) closefile(Apsub)$
```

```
***
```

```

(C3) am1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0])$
(C4) am2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,0,0,0,1])$
(C6) sign:-1$
(C7) cgg1:(gam-1)/gam$
(C8) cgg2:1/(2*gam)$
(C9) xiy:0.0$
(C10) xiz:0.0$
(C11) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C12) axt:xix/sada$
(C13) ayt:xiy/sada$
(C14) azt:xiz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.0$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:0.0$
(C33) dlq1:-ev1*q6$
(C34) dlq2:xix*q6$
(C35) dlq3:xiy*q6$
(C36) dlq4:xiz*q6$
(C37) dlq5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gmlq6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$
(C50) depq1:0.5*gmlq6*rqrq*q6$

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(C51) depq2:-q2*gm1q6\$
 (C52) depq3:-q3*gm1q6\$
 (C53) depq4:-q4*gm1q6\$
 (C54) depq5:gam\$
 (C55) dttq1:-tt*q6\$
 (C56) dttq2:axt*q6\$
 (C57) dttq3:ayt*q6\$
 (C58) dttq4:azt*q6\$
 (C59) dttq5:0.0\$
 (C60) d4q1:sada*(dttq1+dcq1)\$
 (C61) d4q2:sada*(dttq2+dcq2)\$
 (C62) d4q3:sada*(dttq3+dcq3)\$
 (C63) d4q4:sada*(dttq4+dcq4)\$
 (C64) d4q5:sada*dcq5\$
 (C65) d5q1:sada*(dttq1-dcq1)\$
 (C66) d5q2:sada*(dttq2-dcq2)\$
 (C67) d5q3:sada*(dttq3-dcq3)\$
 (C68) d5q4:sada*(dttq4-dcq4)\$
 (C69) d5q5:-d4q5\$
 (C70) a411:ev4+q1*d4q1\$
 (C71) a511:ev5+q1*d5q1\$
 (C72) am1[1,1]:cg2*a411+cg3*a511\$
 (C73) am1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C74) am1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C75) am1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C76) am1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C77) rcaxt:rc*axt\$
 (C78) ev4ax:ev4*axt\$
 (C79) ev5ax:ev5*axt\$
 (C80) coe1:q2+rcaxt\$
 (C81) coe:q2-rcaxt\$
 (C82) a121:q2*d1q1\$
 (C83) a421:ev4ax*drcq1+coe1*d4q1\$
 (C84) a521:-ev5ax*drcq1+coe*d5q1\$
 (C85) am1[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C86) a122:q2*d1q2+ev1\$
 (C87) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C88) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C89) am1[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C90) a123:q2*d1q3\$
 (C91) a423:ev4ax*drcq3+coe1*d4q3\$
 (C92) a523:-ev5ax*drcq3+coe*d5q3\$
 (C93) am1[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C94) a124:q2*d1q4\$
 (C95) a424:ev4ax*drcq4+coe1*d4q4\$
 (C96) a524:-ev5ax*drcq4+coe*d5q4\$
 (C97) am1[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C98) a125:q2*d1q5\$
 (C99) a425:ev4ax*drcq5+coe1*d4q5\$
 (C100) a525:-ev5ax*drcq5+coe*d5q5\$
 (C101) am1[2,5]:cg1*a125+cg2*a425+cg3*a525\$

(C102) rcayt:rc*ayt\$
 (C103) ev4ay:ev4*ayt\$
 (C104) ev5ay:ev5*ayt\$
 (C105) coe1:q3+rcayt\$
 (C106) coe:q3-rcayt\$
 (C107) a131:q3*d1q1\$
 (C108) a431:ev4ay*drcq1+coe1*d4q1\$
 (C109) a531:-ev5ay*drcq1+coe*d5q1\$
 (C110) am1[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C111) a132:q3*d1q2\$
 (C112) a432:ev4ay*drcq2+coe1*d4q2\$
 (C113) a532:-ev5ay*drcq2+coe*d5q2\$
 (C114) am1[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C115) a133:q3*d1q3+ev1\$
 (C116) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C117) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C118) am1[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C119) a134:q3*d1q4\$
 (C120) a434:ev4ay*drcq4+coe1*d4q4\$
 (C121) a534:-ev5ay*drcq4+coe*d5q4\$
 (C122) am1[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C123) a135:q3*d1q5\$
 (C124) a435:ev4ay*drcq5+coe1*d4q5\$
 (C125) a535:-ev5ay*drcq5+coe*d5q5\$
 (C126) am1[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C127) rcazt:rc*azt\$
 (C128) ev4az:ev4*azt\$
 (C129) ev5az:ev5*azt\$
 (C130) coe1:q4+rcazt\$
 (C131) coe:q4-rcazt\$
 (C132) a141:q4*d1q1\$
 (C133) a441:ev4az*drcq1+coe1*d4q1\$
 (C134) a541:-ev5az*drcq1+coe*d5q1\$
 (C135) am1[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C136) a142:q4*d1q2\$
 (C137) a442:ev4az*drcq2+coe1*d4q2\$
 (C138) a542:-ev5az*drcq2+coe*d5q2\$
 (C139) am1[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C140) a143:q4*d1q3\$
 (C141) a443:ev4az*drcq3+coe1*d4q3\$
 (C142) a543:-ev5az*drcq3+coe*d5q3\$
 (C143) am1[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C144) a144:q4*d1q4+ev1\$
 (C145) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C146) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C147) am1[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C148) a145:q4*d1q5\$
 (C149) a445:ev4az*drcq5+coe1*d4q5\$
 (C150) a545:-ev5az*drcq5+coe*d5q5\$
 (C151) am1[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C152) rctt:rc*tt\$

```

(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) am1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) am1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) am1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) am1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) am1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) cgg1:(gam-1)/gam$
(C186) cgg2:1/(2*gam)$
(C187) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C188) axt:xix/sada$
(C189) ayt:xiy/sada$
(C190) azt:xiz/sada$
(C191) rqrq:q2**2+q3**2+q4**2$
(C192) q6:1/q1$
(C193) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C194) prgam:pr*gam$
(C195) pp:q5+pr$
(C196) c:sqrt(prgam*q6)$
(C197) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C198) rc:q1*c$
(C199) csad:c*sada$
(C200) e1:tt*sada$
(C201) e4:e1+csad$
(C202) e5:e1-csad$
(C203) ev1:0.0$

```

```

(C204) ev4:0.0$
(C205) ev5:0.0$
(C206) cg1:0.0$
(C207) cg2:0.0$
(C208) cg3:0.0$
(C209) d1q1:-ev1*q6$
(C210) d1q2:xix*q6$
(C211) d1q3:xiy*q6$
(C212) d1q4:xiz*q6$
(C213) d1q5:0.0$
(C214) coe:gam*(gam-1)/(2*rc)$
(C215) gmlq6:(gam-1)*q6$
(C216) drcq1:coe*q5$
(C217) drcq2:-coe*q2$
(C218) drcq3:-coe*q3$
(C219) drcq4:-coe*q4$
(C220) drcq5:coe*q1$
(C221) dcq1:(drcq1-c)*q6$
(C222) dcq2:drcq2*q6$
(C223) dcq3:drcq3*q6$
(C224) dcq4:drcq4*q6$
(C225) dcq5:drcq5*q6$
(C226) depq1:0.5*gmlq6*rqrq*q6$
(C227) depq2:-q2*gmlq6$
(C228) depq3:-q3*gmlq6$
(C229) depq4:-q4*gmlq6$
(C230) depq5:gam$
(C231) dttq1:-tt*q6$
(C232) dttq2:axt*q6$
(C233) dttq3:ayt*q6$
(C234) dttq4:azt*q6$
(C235) dttq5:0.0$
(C236) d4q1:sada*(dttq1+dcq1)$
(C237) d4q2:sada*(dttq2+dcq2)$
(C238) d4q3:sada*(dttq3+dcq3)$
(C239) d4q4:sada*(dttq4+dcq4)$
(C240) d4q5:sada*dcq5$
(C241) d5q1:sada*(dttq1-dcq1)$
(C242) d5q2:sada*(dttq2-dcq2)$
(C243) d5q3:sada*(dttq3-dcq3)$
(C244) d5q4:sada*(dttq4-dcq4)$
(C245) d5q5:-d4q5$
(C246) a411:ev4+q1*d4q1$
(C247) a511:ev5+q1*d5q1$
(C248) am2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C249) am2[1,1]:cg2*a411+cg3*a511$
(C250) am2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) am2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) am2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253) am2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$

```

(C254) rcaxt:rc*axt\$
 (C255) ev4ax:ev4*axt\$
 (C256) ev5ax:ev5*axt\$
 (C257) coe1:q2+rcaxt\$
 (C258) coe:q2-rcaxt\$
 (C259) a121:q2*d1q1\$
 (C260) a421:ev4ax*drcq1+coe1*d4q1\$
 (C261) a521:-ev5ax*drcq1+coe*d5q1\$
 (C262) am2[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C263) a122:q2*d1q2+ev1\$
 (C264) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C265) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C266) am2[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C267) a123:q2*d1q3\$
 (C268) a423:ev4ax*drcq3+coe1*d4q3\$
 (C269) a523:-ev5ax*drcq3+coe*d5q3\$
 (C270) am2[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C271) a124:q2*d1q4\$
 (C272) a424:ev4ax*drcq4+coe1*d4q4\$
 (C273) a524:-ev5ax*drcq4+coe*d5q4\$
 (C274) am2[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C275) a125:q2*d1q5\$
 (C276) a425:ev4ax*drcq5+coe1*d4q5\$
 (C277) a525:-ev5ax*drcq5+coe*d5q5\$
 (C278) am2[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C279) rcayt:rc*ayt\$
 (C280) ev4ay:ev4*ayt\$
 (C281) ev5ay:ev5*ayt\$
 (C282) coe1:q3+rcayt\$
 (C283) coe:q3-rcayt\$
 (C284) a131:q3*d1q1\$
 (C285) a431:ev4ay*drcq1+coe1*d4q1\$
 (C286) a531:-ev5ay*drcq1+coe*d5q1\$
 (C287) am2[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C288) a132:q3*d1q2\$
 (C289) a432:ev4ay*drcq2+coe1*d4q2\$
 (C290) a532:-ev5ay*drcq2+coe*d5q2\$
 (C291) am2[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C292) a133:q3*d1q3+ev1\$
 (C293) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C294) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C295) am2[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C296) a134:q3*d1q4\$
 (C297) a434:ev4ay*drcq4+coe1*d4q4\$
 (C298) a534:-ev5ay*drcq4+coe*d5q4\$
 (C299) am2[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C300) a135:q3*d1q5\$
 (C301) a435:ev4ay*drcq5+coe1*d4q5\$
 (C302) a535:-ev5ay*drcq5+coe*d5q5\$
 (C303) am2[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C304) rcagt:rc*agt\$

(C305) ev4az:ev4*azt\$
 (C306) ev5az:ev5*azt\$
 (C307) coe1:q4+rcazt\$
 (C308) coe:q4-rcazt\$
 (C309) a141:q4*d1q1\$
 (C310) a441:ev4az*drcq1+coe1*d4q1\$
 (C311) a541:-ev5az*drcq1+coe*d5q1\$
 (C312) am2[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C313) a142:q4*d1q2\$
 (C314) a442:ev4az*drcq2+coe1*d4q2\$
 (C315) a542:-ev5az*drcq2+coe*d5q2\$
 (C316) am2[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C317) a143:q4*d1q3\$
 (C318) a443:ev4az*drcq3+coe1*d4q3\$
 (C319) a543:-ev5az*drcq3+coe*d5q3\$
 (C320) am2[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C321) a144:q4*d1q4+ev1\$
 (C322) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C323) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C324) am2[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C325) a145:q4*d1q5\$
 (C326) a445:ev4az*drcq5+coe1*d4q5\$
 (C327) a545:-ev5az*drcq5+coe*d5q5\$
 (C328) am2[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C329) rctt:rc*tt\$
 (C330) coe:0.5*(q2**2+q3**2+q4**2)*q6\$
 (C331) rt:rc*dttq1+tt*drcq1\$
 (C332) a151:2*coe*d1q1\$
 (C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$
 (C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$
 (C335) am2[5,1]:cg1*a151+cg2*a451+cg3*a551\$
 (C336) rt:rc*dttq2+tt*drcq2\$
 (C337) a152:coe*d1q2-d1q1*q2\$
 (C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$
 (C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$
 (C340) am2[5,2]:cg1*a152+cg2*a452+cg3*a552\$
 (C341) rt:rc*dttq3+tt*drcq3\$
 (C342) a153:coe*d1q3-d1q1*q3\$
 (C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$
 (C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$
 (C345) am2[5,3]:cg1*a153+cg2*a453+cg3*a553\$
 (C346) rt:rc*dttq4+tt*drcq4\$
 (C347) a154:coe*d1q4-d1q1*q4\$
 (C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$
 (C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$
 (C350) am2[5,4]:cg1*a154+cg2*a454+cg3*a554\$
 (C351) rt:tt*drcq5\$
 (C352) a155:coe*d1q5\$
 (C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$
 (C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$
 (C355) am2[5,5]:cg1*a155+cg2*a455+cg3*a555\$

AMSUP

```
(C356) diff:am1.m-m.am1$
(C357) diff:ratexpand(diff);
```

```
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
```

```
(D357)
```

```
(C358) closefile(Amsup)$
```

```
■
```

```

(C3) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C4) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C5) sign:1$
(C6) cgg1:(gam-1)/gam$
(C7) cgg2:1/(2*gam)$
(C8) xiy:0.0$
(C9) xiz:0.0$
(C10) sada:sqrt(xix**2+xiy**2+xiz**2)$
(C11) axt:xix/sada$
(C12) ayt:xiy/sada$
(C13) azt:xiz/sada$
(C14) rqrq:q2**2+q3**2+q4**2$
(C15) q6:1/q1$
(C16) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17) prgam:pr*gam$
(C18) pp:q5+pr$
(C19) c:sqrt(prgam*q6)$
(C20) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21) rc:q1*c$
(C22) csad:c*sada$
(C23) e1:tt*sada$
(C24) e4:e1+csad$
(C25) e5:e1-csad$
(C26) ev1:0.0$
(C27) ev4:0.0$
(C28) ev5:0.5*(e5+sign*abs(e5))$
(C29) cg1:0.0$
(C30) cg2:0.0$
(C31) cg3:cgg2$
(C32) dlq1:-ev1*q6$
(C33) dlq2:xix*q6$
(C34) dlq3:xiy*q6$
(C35) dlq4:xiz*q6$
(C36) dlq5:0.0$
(C37) coe:gam*(gam-1)/(2*rc)$
(C38) gmlq6:(gam-1)*q6$
(C39) drcq1:coe*q5$
(C40) drcq2:-coe*q2$
(C41) drcq3:-coe*q3$
(C42) drcq4:-coe*q4$
(C43) drcq5:coe*q1$
(C44) dcq1:(drcq1-c)*q6$
(C45) dcq2:drcq2*q6$
(C46) dcq3:drcq3*q6$
(C47) dcq4:drcq4*q6$
(C48) dcq5:drcq5*q6$
(C49) depq1:0.5*gmlq6*rqrq*q6$
(C50) depq2:-q2*gmlq6$
(C51) depq3:-q3*gmlq6$

```

```

(C52) depq4:-q4*gm1q6$
(C53) depq5:gam$
(C54) dttq1:-tt*q6$
(C55) dttq2:axt*q6$
(C56) dttq3:ayt*q6$
(C57) dttq4:azt*q6$
(C58) dttq5:0.0$
(C59) d4q1:sada*(dttq1+dcq1)$
(C60) d4q2:sada*(dttq2+dcq2)$
(C61) d4q3:sada*(dttq3+dcq3)$
(C62) d4q4:sada*(dttq4+dcq4)$
(C63) d4q5:sada*dcq5$
(C64) d5q1:sada*(dttq1-dcq1)$
(C65) d5q2:sada*(dttq2-dcq2)$
(C66) d5q3:sada*(dttq3-dcq3)$
(C67) d5q4:sada*(dttq4-dcq4)$
(C68) d5q5:-d4q5$
(C69) a411:ev4+q1*d4q1$
(C70) a511:ev5+q1*d5q1$
(C71) ap1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C72) ap2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C73) ap1[1,1]:cg2*a411+cg3*a511$
(C74) ap1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C75) ap1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C76) ap1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C77) ap1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C78) rcaxt:rc*axt$
(C79) ev4ax:ev4*axt$
(C80) ev5ax:ev5*axt$
(C81) coe1:q2+rcaxt$
(C82) coe:q2-rcaxt$
(C83) a121:q2*d1q1$
(C84) a421:ev4ax*drcq1+coe1*d4q1$
(C85) a521:-ev5ax*drcq1+coe*d5q1$
(C86) ap1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C87) a122:q2*d1q2+ev1$
(C88) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C89) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C90) ap1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C91) a123:q2*d1q3$
(C92) a423:ev4ax*drcq3+coe1*d4q3$
(C93) a523:-ev5ax*drcq3+coe*d5q3$
(C94) ap1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C95) a124:q2*d1q4$
(C96) a424:ev4ax*drcq4+coe1*d4q4$
(C97) a524:-ev5ax*drcq4+coe*d5q4$
(C98) ap1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C99) a125:q2*d1q5$
(C100) a425:ev4ax*drcq5+coe1*d4q5$

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(C101) a525:-ev5ax*drcq5+coe*d5q5\$
 (C102) ap1[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C103) rcayt:rc*ayt\$
 (C104) ev4ay:ev4*ayt\$
 (C105) ev5ay:ev5*ayt\$
 (C106) coe1:q3+rcayt\$
 (C107) coe:q3-rcayt\$
 (C108) a131:q3*d1q1\$
 (C109) a431:ev4ay*drcq1+coe1*d4q1\$
 (C110) a531:-ev5ay*drcq1+coe*d5q1\$
 (C111) ap1[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C112) a132:q3*d1q2\$
 (C113) a432:ev4ay*drcq2+coe1*d4q2\$
 (C114) a532:-ev5ay*drcq2+coe*d5q2\$
 (C115) ap1[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C116) a133:q3*d1q3+ev1\$
 (C117) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C118) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C119) ap1[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C120) a134:q3*d1q4\$
 (C121) a434:ev4ay*drcq4+coe1*d4q4\$
 (C122) a534:-ev5ay*drcq4+coe*d5q4\$
 (C123) ap1[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C124) a135:q3*d1q5\$
 (C125) a435:ev4ay*drcq5+coe1*d4q5\$
 (C126) a535:-ev5ay*drcq5+coe*d5q5\$
 (C127) ap1[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C128) rcazt:rc*azt\$
 (C129) ev4az:ev4*azt\$
 (C130) ev5az:ev5*azt\$
 (C131) coe1:q4+rcazt\$
 (C132) coe:q4-rcazt\$
 (C133) a141:q4*d1q1\$
 (C134) a441:ev4az*drcq1+coe1*d4q1\$
 (C135) a541:-ev5az*drcq1+coe*d5q1\$
 (C136) ap1[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C137) a142:q4*d1q2\$
 (C138) a442:ev4az*drcq2+coe1*d4q2\$
 (C139) a542:-ev5az*drcq2+coe*d5q2\$
 (C140) ap1[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C141) a143:q4*d1q3\$
 (C142) a443:ev4az*drcq3+coe1*d4q3\$
 (C143) a543:-ev5az*drcq3+coe*d5q3\$
 (C144) ap1[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C145) a144:q4*d1q4+ev1\$
 (C146) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C147) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C148) ap1[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C149) a145:q4*d1q5\$
 (C150) a445:ev4az*drcq5+coe1*d4q5\$
 (C151) a545:-ev5az*drcq5+coe*d5q5\$

(C152) $ap1[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C153) $rctt:rc*tt\$$
 (C154) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C155) $rt:rc*dttq1+tt*drcq1\$$
 (C156) $a151:2*coe*d1q1\$$
 (C157) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C158) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C159) $ap1[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C160) $rt:rc*dttq2+tt*drcq2\$$
 (C161) $a152:coe*d1q2-d1q1*q2\$$
 (C162) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C163) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C164) $ap1[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C165) $rt:rc*dttq3+tt*drcq3\$$
 (C166) $a153:coe*d1q3-d1q1*q3\$$
 (C167) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C168) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C169) $ap1[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C170) $rt:rc*dttq4+tt*drcq4\$$
 (C171) $a154:coe*d1q4-d1q1*q4\$$
 (C172) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C173) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C174) $ap1[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C175) $rt:tt*drcq5\$$
 (C176) $a155:coe*d1q5\$$
 (C177) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$
 (C178) $a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$$
 (C179) $ap1[5,5]:cg1*a155+cg2*a455+cg3*a555\$$
 (C180) $q1:q1\$$
 (C181) $q2:q2\$$
 (C182) $q3:q3\$$
 (C183) $q4:-q4\$$
 (C184) $q5:q5\$$
 (C185) $sign:1\$$
 (C186) $cggl:(gam-1)/gam\$$
 (C187) $cggl:1/(2*gam)\$$
 (C188) $sada:sqrt(xix**2+xiy**2+xiz**2)\$$
 (C189) $axt:xix/sada\$$
 (C190) $ayt:xiy/sada\$$
 (C191) $azt:xiz/sada\$$
 (C192) $rqrq:q2**2+q3**2+q4**2\$$
 (C193) $q6:1/q1\$$
 (C194) $pr:(gam-1)*(q5-0.5*rqrq*q6)\$$
 (C195) $prgam:pr*gam\$$
 (C196) $pp:q5+pr\$$
 (C197) $c:sqrt(prgam*q6)\$$
 (C198) $tt:(q2*axt+q3*ayt+q4*azt)*q6\$$
 (C199) $rc:q1*c\$$
 (C200) $csad:c*sada\$$
 (C201) $e1:tt*sada\$$
 (C202) $e4:e1+csad\$$

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(C203) e5:e1-csad$
(C204) ev1:0.0$
(C205) ev4:0.0$
(C206) ev5:0.5*(e5+sign*abs(e5))$
(C207) cg1:0.0$
(C208) cg2:0.0$
(C209) cg3:cg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:xix*q6$
(C212) d1q3:xiy*q6$
(C213) d1q4:xiz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gm1q6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gm1q6*rqrq*q6$
(C228) depq2:-q2*gm1q6$
(C229) depq3:-q3*gm1q6$
(C230) depq4:-q4*gm1q6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) ap2[1,1]:cg2*a411+cg3*a511$
(C250) ap2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C251) ap2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C252) ap2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C253) ap2[1,5]:(cg2*d4q5+cg3*d5q5)*q1$

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(C254) rcaxt:rc*axt\$
 (C255) ev4ax:ev4*axt\$
 (C256) ev5ax:ev5*axt\$
 (C257) coe1:q2+rcaxt\$
 (C258) coe:q2-rcaxt\$
 (C259) a121:q2*d1q1\$
 (C260) a421:ev4ax*drcq1+coe1*d4q1\$
 (C261) a521:-ev5ax*drcq1+coe*d5q1\$
 (C262) ap2[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C263) a122:q2*d1q2+ev1\$
 (C264) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C265) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C266) ap2[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C267) a123:q2*d1q3\$
 (C268) a423:ev4ax*drcq3+coe1*d4q3\$
 (C269) a523:-ev5ax*drcq3+coe*d5q3\$
 (C270) ap2[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C271) a124:q2*d1q4\$
 (C272) a424:ev4ax*drcq4+coe1*d4q4\$
 (C273) a524:-ev5ax*drcq4+coe*d5q4\$
 (C274) ap2[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C275) a125:q2*d1q5\$
 (C276) a425:ev4ax*drcq5+coe1*d4q5\$
 (C277) a525:-ev5ax*drcq5+coe*d5q5\$
 (C278) ap2[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C279) rcayt:rc*ayt\$
 (C280) ev4ay:ev4*ayt\$
 (C281) ev5ay:ev5*ayt\$
 (C282) coe1:q3+rcayt\$
 (C283) coe:q3-rcayt\$
 (C284) a131:q3*d1q1\$
 (C285) a431:ev4ay*drcq1+coe1*d4q1\$
 (C286) a531:-ev5ay*drcq1+coe*d5q1\$
 (C287) ap2[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C288) a132:q3*d1q2\$
 (C289) a432:ev4ay*drcq2+coe1*d4q2\$
 (C290) a532:-ev5ay*drcq2+coe*d5q2\$
 (C291) ap2[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C292) a133:q3*d1q3+ev1\$
 (C293) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C294) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C295) ap2[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C296) a134:q3*d1q4\$
 (C297) a434:ev4ay*drcq4+coe1*d4q4\$
 (C298) a534:-ev5ay*drcq4+coe*d5q4\$
 (C299) ap2[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C300) a135:q3*d1q5\$
 (C301) a435:ev4ay*drcq5+coe1*d4q5\$
 (C302) a535:-ev5ay*drcq5+coe*d5q5\$
 (C303) ap2[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C304) rcazt:rc*azt\$

(C305) ev4az:ev4*azt\$
 (C306) ev5az:ev5*azt\$
 (C307) coe1:q4+rcazt\$
 (C308) coe:q4-rcazt\$
 (C309) a141:q4*d1q1\$
 (C310) a441:ev4az*drcq1+coe1*d4q1\$
 (C311) a541:-ev5az*drcq1+coe*d5q1\$
 (C312) ap2[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C313) a142:q4*d1q2\$
 (C314) a442:ev4az*drcq2+coe1*d4q2\$
 (C315) a542:-ev5az*drcq2+coe*d5q2\$
 (C316) ap2[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C317) a143:q4*d1q3\$
 (C318) a443:ev4az*drcq3+coe1*d4q3\$
 (C319) a543:-ev5az*drcq3+coe*d5q3\$
 (C320) ap2[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C321) a144:q4*d1q4+ev1\$
 (C322) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C323) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C324) ap2[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C325) a145:q4*d1q5\$
 (C326) a445:ev4az*drcq5+coe1*d4q5\$
 (C327) a545:-ev5az*drcq5+coe*d5q5\$
 (C328) ap2[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C329) rctt:rc*tt\$
 (C330) coe:0.5*(q2**2+q3**2+q4**2)*q6\$
 (C331) rt:rc*dttq1+tt*drcq1\$
 (C332) a151:2*coe*d1q1\$
 (C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$
 (C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$
 (C335) ap2[5,1]:cg1*a151+cg2*a451+cg3*a551\$
 (C336) rt:rc*dttq2+tt*drcq2\$
 (C337) a152:coe*d1q2-d1q1*q2\$
 (C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$
 (C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$
 (C340) ap2[5,2]:cg1*a152+cg2*a452+cg3*a552\$
 (C341) rt:rc*dttq3+tt*drcq3\$
 (C342) a153:coe*d1q3-d1q1*q3\$
 (C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$
 (C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$
 (C345) ap2[5,3]:cg1*a153+cg2*a453+cg3*a553\$
 (C346) rt:rc*dttq4+tt*drcq4\$
 (C347) a154:coe*d1q4-d1q1*q4\$
 (C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$
 (C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$
 (C350) ap2[5,4]:cg1*a154+cg2*a454+cg3*a554\$
 (C351) rt:tt*drcq5\$
 (C352) a155:coe*d1q5\$
 (C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$
 (C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$
 (C355) ap2[5,5]:cg1*a155+cg2*a455+cg3*a555\$

AMSUB

(C356) diff:ap1.m-m.ap2\$
(C357) diff:ratexpand(diff);

(D357)

(C358) closefile(Amsub)\$

```
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]
```

```

(C3) bp1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0])$
(C4) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.5*(e1+sign*abs(e1))$
(C28) ev4:0.5*(e4+sign*abs(e4))$
(C29) ev5:0.5*(e5+sign*abs(e5))$
(C30) cg1:cgg1$
(C31) cg2:cgg2$
(C32) cg3:cgg2$
(C33) dlq1:-ev1*q6$
(C34) dlq2:etx*q6$
(C35) dlq3:ety*q6$
(C36) dlq4:etz*q6$
(C37) dlq5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gmlq6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$

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(C50) depq1:0.5*gm1q6*rqrq*q6\$
 (C51) depq2:-q2*gm1q6\$
 (C52) depq3:-q3*gm1q6\$
 (C53) depq4:-q4*gm1q6\$
 (C54) depq5:gam\$
 (C55) dttq1:-tt*q6\$
 (C56) dttq2:axt*q6\$
 (C57) dttq3:ayt*q6\$
 (C58) dttq4:azt*q6\$
 (C59) dttq5:0.0\$
 (C60) d4q1:sada*(dttq1+dcq1)\$
 (C61) d4q2:sada*(dttq2+dcq2)\$
 (C62) d4q3:sada*(dttq3+dcq3)\$
 (C63) d4q4:sada*(dttq4+dcq4)\$
 (C64) d4q5:sada*dcq5\$
 (C65) d5q1:sada*(dttq1-dcq1)\$
 (C66) d5q2:sada*(dttq2-dcq2)\$
 (C67) d5q3:sada*(dttq3-dcq3)\$
 (C68) d5q4:sada*(dttq4-dcq4)\$
 (C69) d5q5:-d4q5\$
 (C70) a411:ev4+q1*d4q1\$
 (C71) a511:ev5+q1*d5q1\$
 (C72) bp1[1,1]:cg2*a411+cg3*a511\$
 (C73) bp1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C74) bp1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C75) bp1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C76) bp1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C77) rcaxt:rc*axt\$
 (C78) ev4ax:ev4*axt\$
 (C79) ev5ax:ev5*axt\$
 (C80) coe1:q2+rcaxt\$
 (C81) coe:q2-rcaxt\$
 (C82) a121:q2*d1q1\$
 (C83) a421:ev4ax*drcq1+coe1*d4q1\$
 (C84) a521:-ev5ax*drcq1+coe*d5q1\$
 (C85) bp1[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C86) a122:q2*d1q2+ev1\$
 (C87) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C88) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C89) bp1[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C90) a123:q2*d1q3\$
 (C91) a423:ev4ax*drcq3+coe1*d4q3\$
 (C92) a523:-ev5ax*drcq3+coe*d5q3\$
 (C93) bp1[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C94) a124:q2*d1q4\$
 (C95) a424:ev4ax*drcq4+coe1*d4q4\$
 (C96) a524:-ev5ax*drcq4+coe*d5q4\$
 (C97) bp1[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C98) a125:q2*d1q5\$
 (C99) a425:ev4ax*drcq5+coe1*d4q5\$
 (C100) a525:-ev5ax*drcq5+coe*d5q5\$

(C101) $bp1[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C102) $rcayt:rc*ayt\$$
 (C103) $ev4ay:ev4*ayt\$$
 (C104) $ev5ay:ev5*ayt\$$
 (C105) $coe1:q3+rcayt\$$
 (C106) $coe:q3-rcayt\$$
 (C107) $a131:q3*d1q1\$$
 (C108) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C109) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C110) $bp1[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C111) $a132:q3*d1q2\$$
 (C112) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C113) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C114) $bp1[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C115) $a133:q3*d1q3+ev1\$$
 (C116) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C117) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C118) $bp1[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C119) $a134:q3*d1q4\$$
 (C120) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C121) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C122) $bp1[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C123) $a135:q3*d1q5\$$
 (C124) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C125) $a535:-ev5ay*drcq5+coe*d5q5\$$
 (C126) $bp1[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C127) $rcazt:rc*azt\$$
 (C128) $ev4az:ev4*azt\$$
 (C129) $ev5az:ev5*azt\$$
 (C130) $coe1:q4+rcazt\$$
 (C131) $coe:q4-rcazt\$$
 (C132) $a141:q4*d1q1\$$
 (C133) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C134) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C135) $bp1[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C136) $a142:q4*d1q2\$$
 (C137) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C138) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C139) $bp1[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C140) $a143:q4*d1q3\$$
 (C141) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C142) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C143) $bp1[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C144) $a144:q4*d1q4+ev1\$$
 (C145) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C146) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C147) $bp1[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C148) $a145:q4*d1q5\$$
 (C149) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C150) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C151) $bp1[4,5]:cg1*a145+cg2*a445+cg3*a545\$$

```

(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bp1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bp1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bp1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bp1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bp1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) etz:-etz;
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(etx**2+ety**2+etz**2)$
(C189) axt:etx/sada$
(C190) ayt:ety/sada$
(C191) azt:etz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$

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(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.5*(e5+sign*abs(e5))$
(C207) cg1:cg1$
(C208) cg2:cg2$
(C209) cg3:cg2$
(C210) d1q1:-ev1*q6$
(C211) d1q2:etx*q6$
(C212) d1q3:ety*q6$
(C213) d1q4:etz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gmlq6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gmlq6*rqrq*q6$
(C228) depq2:-q2*gmlq6$
(C229) depq3:-q3*gmlq6$
(C230) depq4:-q4*gmlq6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) bp2[1,1]:cg2*a411+cg3*a511$
(C251) bp2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) bp2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$

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(C253) $bp2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C254) $bp2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C255) $rcaxt:rc*axt\$$
 (C256) $ev4ax:ev4*axt\$$
 (C257) $ev5ax:ev5*axt\$$
 (C258) $coe1:q2+rcaxt\$$
 (C259) $coe:q2-rcaxt\$$
 (C260) $a121:q2*d1q1\$$
 (C261) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C262) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C263) $bp2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C264) $a122:q2*d1q2+ev1\$$
 (C265) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C266) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C267) $bp2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C268) $a123:q2*d1q3\$$
 (C269) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C270) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C271) $bp2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C272) $a124:q2*d1q4\$$
 (C273) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C274) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C275) $bp2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C276) $a125:q2*d1q5\$$
 (C277) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C278) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C279) $bp2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C280) $rcayt:rc*ayt\$$
 (C281) $ev4ay:ev4*ayt\$$
 (C282) $ev5ay:ev5*ayt\$$
 (C283) $coe1:q3+rcayt\$$
 (C284) $coe:q3-rcayt\$$
 (C285) $a131:q3*d1q1\$$
 (C286) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C287) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C288) $bp2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C289) $a132:q3*d1q2\$$
 (C290) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C291) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C292) $bp2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C293) $a133:q3*d1q3+ev1\$$
 (C294) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C295) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C296) $bp2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C297) $a134:q3*d1q4\$$
 (C298) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C299) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C300) $bp2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C301) $a135:q3*d1q5\$$
 (C302) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C303) $a535:-ev5ay*drcq5+coe*d5q5\$$

(C304) $bp2[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C305) $rcazt:rc*azt\$$
 (C306) $ev4az:ev4*azt\$$
 (C307) $ev5az:ev5*azt\$$
 (C308) $coe1:q4+rcazt\$$
 (C309) $coe:q4-rcazt\$$
 (C310) $a141:q4*d1q1\$$
 (C311) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C312) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C313) $bp2[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C314) $a142:q4*d1q2\$$
 (C315) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C316) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C317) $bp2[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C318) $a143:q4*d1q3\$$
 (C319) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C320) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C321) $bp2[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C322) $a144:q4*d1q4+ev1\$$
 (C323) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C324) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C325) $bp2[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C326) $a145:q4*d1q5\$$
 (C327) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C328) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C329) $bp2[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C330) $rctt:rc*tt\$$
 (C331) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C332) $rt:rc*dttq1+tt*drcq1\$$
 (C333) $a151:2*coe*d1q1\$$
 (C334) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C335) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C336) $bp2[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C337) $rt:rc*dttq2+tt*drcq2\$$
 (C338) $a152:coe*d1q2-d1q1*q2\$$
 (C339) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C340) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C341) $bp2[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C342) $rt:rc*dttq3+tt*drcq3\$$
 (C343) $a153:coe*d1q3-d1q1*q3\$$
 (C344) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C345) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C346) $bp2[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C347) $rt:rc*dttq4+tt*drcq4\$$
 (C348) $a154:coe*d1q4-d1q1*q4\$$
 (C349) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C350) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C351) $bp2[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C352) $rt:tt*drcq5\$$
 (C353) $a155:coe*d1q5\$$
 (C354) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$

BPSUP

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bp2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bp1.m-m.bp2$
(C358) diff:ratexpand(diff);
```

```
(D358)
```

```
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
```

```
(C359) closefile(Bpsup)$
```

■

```

(C3) bp1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.5*(e1+sign*abs(e1))$
(C28) ev4:0.5*(e4+sign*abs(e4))$
(C29) ev5:0.0$
(C30) cg1:cgg1$
(C31) cg2:cgg2$
(C32) cg3:0.0$
(C33) dlq1:-ev1*q6$
(C34) dlq2:etx*q6$
(C35) dlq3:ety*q6$
(C36) dlq4:etz*q6$
(C37) dlq5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gmlq6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$

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```

(C50) depq1:0.5*gm1q6*rqrq*q6$
(C51) depq2:-q2*gm1q6$
(C52) depq3:-q3*gm1q6$
(C53) depq4:-q4*gm1q6$
(C54) depq5:gam$
(C55) dttq1:-tt*q6$
(C56) dttq2:axt*q6$
(C57) dttq3:ayt*q6$
(C58) dttq4:azt*q6$
(C59) dttq5:0.0$
(C60) d4q1:sada*(dttq1+dcq1)$
(C61) d4q2:sada*(dttq2+dcq2)$
(C62) d4q3:sada*(dttq3+dcq3)$
(C63) d4q4:sada*(dttq4+dcq4)$
(C64) d4q5:sada*dcq5$
(C65) d5q1:sada*(dttq1-dcq1)$
(C66) d5q2:sada*(dttq2-dcq2)$
(C67) d5q3:sada*(dttq3-dcq3)$
(C68) d5q4:sada*(dttq4-dcq4)$
(C69) d5q5:-d4q5$
(C70) a411:ev4+q1*d4q1$
(C71) a511:ev5+q1*d5q1$
(C72) bp1[1,1]:cg2*a411+cg3*a511$
(C73) bp1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C74) bp1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$
(C75) bp1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1$
(C76) bp1[1,5]:(cg2*d4q5+cg3*d5q5)*q1$
(C77) rcaxt:rc*axt$
(C78) ev4ax:ev4*axt$
(C79) ev5ax:ev5*axt$
(C80) coe1:q2+rcaxt$
(C81) coe:q2-rcaxt$
(C82) a121:q2*d1q1$
(C83) a421:ev4ax*drcq1+coe1*d4q1$
(C84) a521:-ev5ax*drcq1+coe*d5q1$
(C85) bp1[2,1]:cg1*a121+cg2*a421+cg3*a521$
(C86) a122:q2*d1q2+ev1$
(C87) a422:ev4+ev4ax*drcq2+coe1*d4q2$
(C88) a522:ev5-ev5ax*drcq2+coe*d5q2$
(C89) bp1[2,2]:cg1*a122+cg2*a422+cg3*a522$
(C90) a123:q2*d1q3$
(C91) a423:ev4ax*drcq3+coe1*d4q3$
(C92) a523:-ev5ax*drcq3+coe*d5q3$
(C93) bp1[2,3]:cg1*a123+cg2*a423+cg3*a523$
(C94) a124:q2*d1q4$
(C95) a424:ev4ax*drcq4+coe1*d4q4$
(C96) a524:-ev5ax*drcq4+coe*d5q4$
(C97) bp1[2,4]:cg1*a124+cg2*a424+cg3*a524$
(C98) a125:q2*d1q5$
(C99) a425:ev4ax*drcq5+coe1*d4q5$
(C100) a525:-ev5ax*drcq5+coe*d5q5$

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(C101) bp1[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C102) rcayt:rc*ayt\$
 (C103) ev4ay:ev4*ayt\$
 (C104) ev5ay:ev5*ayt\$
 (C105) coe1:q3+rcayt\$
 (C106) coe:q3-rcayt\$
 (C107) a131:q3*d1q1\$
 (C108) a431:ev4ay*drcq1+coe1*d4q1\$
 (C109) a531:-ev5ay*drcq1+coe*d5q1\$
 (C110) bp1[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C111) a132:q3*d1q2\$
 (C112) a432:ev4ay*drcq2+coe1*d4q2\$
 (C113) a532:-ev5ay*drcq2+coe*d5q2\$
 (C114) bp1[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C115) a133:q3*d1q3+ev1\$
 (C116) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C117) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C118) bp1[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C119) a134:q3*d1q4\$
 (C120) a434:ev4ay*drcq4+coe1*d4q4\$
 (C121) a534:-ev5ay*drcq4+coe*d5q4\$
 (C122) bp1[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C123) a135:q3*d1q5\$
 (C124) a435:ev4ay*drcq5+coe1*d4q5\$
 (C125) a535:-ev5ay*drcq5+coe*d5q5\$
 (C126) bp1[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C127) rcazt:rc*azt\$
 (C128) ev4az:ev4*azt\$
 (C129) ev5az:ev5*azt\$
 (C130) coe1:q4+rcazt\$
 (C131) coe:q4-rcast\$
 (C132) a141:q4*d1q1\$
 (C133) a441:ev4az*drcq1+coe1*d4q1\$
 (C134) a541:-ev5az*drcq1+coe*d5q1\$
 (C135) bp1[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C136) a142:q4*d1q2\$
 (C137) a442:ev4az*drcq2+coe1*d4q2\$
 (C138) a542:-ev5az*drcq2+coe*d5q2\$
 (C139) bp1[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C140) a143:q4*d1q3\$
 (C141) a443:ev4az*drcq3+coe1*d4q3\$
 (C142) a543:-ev5az*drcq3+coe*d5q3\$
 (C143) bp1[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C144) a144:q4*d1q4+ev1\$
 (C145) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C146) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C147) bp1[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C148) a145:q4*d1q5\$
 (C149) a445:ev4az*drcq5+coe1*d4q5\$
 (C150) a545:-ev5az*drcq5+coe*d5q5\$
 (C151) bp1[4,5]:cg1*a145+cg2*a445+cg3*a545\$

```

(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bp1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bp1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bp1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bp1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bp1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) etz:-etz;
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(etx**2+ety**2+etz**2)$
(C189) axt:etx/sada$
(C190) ayt:ety/sada$
(C191) azt:etz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$

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(C203) e5:e1-csad$
(C204) ev1:0.5*(e1+sign*abs(e1))$
(C205) ev4:0.5*(e4+sign*abs(e4))$
(C206) ev5:0.0$
(C207) cg1:cgq1$
(C208) cg2:cgq2$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:etx*q6$
(C212) d1q3:ety*q6$
(C213) d1q4:etz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gmlq6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gmlq6*rqrq*q6$
(C228) depq2:-q2*gmlq6$
(C229) depq3:-q3*gmlq6$
(C230) depq4:-q4*gmlq6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) bp2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) bp2[1,1]:cg2*a411+cg3*a511$
(C251) bp2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) bp2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$

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(C253) $bp2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C254) $bp2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C255) $rcaxt:rc*axt\$$
 (C256) $ev4ax:ev4*axt\$$
 (C257) $ev5ax:ev5*axt\$$
 (C258) $coe1:q2+rcaxt\$$
 (C259) $coe:q2-rcaxt\$$
 (C260) $a121:q2*d1q1\$$
 (C261) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C262) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C263) $bp2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C264) $a122:q2*d1q2+ev1\$$
 (C265) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C266) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C267) $bp2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C268) $a123:q2*d1q3\$$
 (C269) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C270) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C271) $bp2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C272) $a124:q2*d1q4\$$
 (C273) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C274) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C275) $bp2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C276) $a125:q2*d1q5\$$
 (C277) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C278) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C279) $bp2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C280) $rcayt:rc*ayt\$$
 (C281) $ev4ay:ev4*ayt\$$
 (C282) $ev5ay:ev5*ayt\$$
 (C283) $coe1:q3+rcayt\$$
 (C284) $coe:q3-rcayt\$$
 (C285) $a131:q3*d1q1\$$
 (C286) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C287) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C288) $bp2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C289) $a132:q3*d1q2\$$
 (C290) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C291) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C292) $bp2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C293) $a133:q3*d1q3+ev1\$$
 (C294) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C295) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C296) $bp2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C297) $a134:q3*d1q4\$$
 (C298) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C299) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C300) $bp2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C301) $a135:q3*d1q5\$$
 (C302) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C303) $a535:-ev5ay*drcq5+coe*d5q5\$$

(C304) $bp2[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C305) $rcazt:rc*azt\$$
 (C306) $ev4az:ev4*azt\$$
 (C307) $ev5az:ev5*azt\$$
 (C308) $coe1:q4+rcazt\$$
 (C309) $coe:q4-rcazt\$$
 (C310) $a141:q4*d1q1\$$
 (C311) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C312) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C313) $bp2[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C314) $a142:q4*d1q2\$$
 (C315) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C316) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C317) $bp2[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C318) $a143:q4*d1q3\$$
 (C319) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C320) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C321) $bp2[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C322) $a144:q4*d1q4+ev1\$$
 (C323) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C324) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C325) $bp2[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C326) $a145:q4*d1q5\$$
 (C327) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C328) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C329) $bp2[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C330) $rctt:rc*tt\$$
 (C331) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C332) $rt:rc*dttq1+tt*drcq1\$$
 (C333) $a151:2*coe*d1q1\$$
 (C334) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C335) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C336) $bp2[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C337) $rt:rc*dttq2+tt*drcq2\$$
 (C338) $a152:coe*d1q2-d1q1*q2\$$
 (C339) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C340) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C341) $bp2[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C342) $rt:rc*dttq3+tt*drcq3\$$
 (C343) $a153:coe*d1q3-d1q1*q3\$$
 (C344) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C345) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C346) $bp2[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C347) $rt:rc*dttq4+tt*drcq4\$$
 (C348) $a154:coe*d1q4-d1q1*q4\$$
 (C349) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C350) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C351) $bp2[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C352) $rt:tt*drcq5\$$
 (C353) $a155:coe*d1q5\$$
 (C354) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$

BPSUB

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bp2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bp1.m-m.bp2$
(C358) diff:ratexpand(diff);
```

```
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
```

```
(D358)
```

```
(C359) closefile(Bpsub)$
```



```

(C3) bm1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:-1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.0$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:0.0$
(C33) dlq1:-ev1*q6$
(C34) dlq2:etx*q6$
(C35) dlq3:ety*q6$
(C36) dlq4:etz*q6$
(C37) dlq5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gmlq6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$

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(C50) depq1:0.5*gmlq6*rqrq*q6\$
 (C51) depq2:-q2*gmlq6\$
 (C52) depq3:-q3*gmlq6\$
 (C53) depq4:-q4*gmlq6\$
 (C54) depq5:gam\$
 (C55) dttq1:-tt*q6\$
 (C56) dttq2:axt*q6\$
 (C57) dttq3:ayt*q6\$
 (C58) dttq4:azt*q6\$
 (C59) dttq5:0.0\$
 (C60) d4q1:sada*(dttq1+dcq1)\$
 (C61) d4q2:sada*(dttq2+dcq2)\$
 (C62) d4q3:sada*(dttq3+dcq3)\$
 (C63) d4q4:sada*(dttq4+dcq4)\$
 (C64) d4q5:sada*dcq5\$
 (C65) d5q1:sada*(dttq1-dcq1)\$
 (C66) d5q2:sada*(dttq2-dcq2)\$
 (C67) d5q3:sada*(dttq3-dcq3)\$
 (C68) d5q4:sada*(dttq4-dcq4)\$
 (C69) d5q5:-d4q5\$
 (C70) a411:ev4+q1*d4q1\$
 (C71) a511:ev5+q1*d5q1\$
 (C72) bm1[1,1]:cg2*a411+cg3*a511\$
 (C73) bm1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C74) bm1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C75) bm1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C76) bm1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C77) rcaxt:rc*axt\$
 (C78) ev4ax:ev4*axt\$
 (C79) ev5ax:ev5*axt\$
 (C80) coe1:q2+rcaxt\$
 (C81) coe:q2-rcaxt\$
 (C82) a121:q2*d1q1\$
 (C83) a421:ev4ax*drcq1+coe1*d4q1\$
 (C84) a521:-ev5ax*drcq1+coe*d5q1\$
 (C85) bm1[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C86) a122:q2*d1q2+ev1\$
 (C87) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C88) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C89) bm1[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C90) a123:q2*d1q3\$
 (C91) a423:ev4ax*drcq3+coe1*d4q3\$
 (C92) a523:-ev5ax*drcq3+coe*d5q3\$
 (C93) bm1[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C94) a124:q2*d1q4\$
 (C95) a424:ev4ax*drcq4+coe1*d4q4\$
 (C96) a524:-ev5ax*drcq4+coe*d5q4\$
 (C97) bm1[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C98) a125:q2*d1q5\$
 (C99) a425:ev4ax*drcq5+coe1*d4q5\$
 (C100) a525:-ev5ax*drcq5+coe*d5q5\$

(C101) $bm1[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C102) $rcayt:rc*ayt\$$
 (C103) $ev4ay:ev4*ayt\$$
 (C104) $ev5ay:ev5*ayt\$$
 (C105) $coel:q3+rcayt\$$
 (C106) $coe:q3-rcayt\$$
 (C107) $a131:q3*d1q1\$$
 (C108) $a431:ev4ay*drcq1+coel*d4q1\$$
 (C109) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C110) $bm1[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C111) $a132:q3*d1q2\$$
 (C112) $a432:ev4ay*drcq2+coel*d4q2\$$
 (C113) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C114) $bm1[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C115) $a133:q3*d1q3+ev1\$$
 (C116) $a433:ev4+ev4ay*drcq3+coel*d4q3\$$
 (C117) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C118) $bm1[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C119) $a134:q3*d1q4\$$
 (C120) $a434:ev4ay*drcq4+coel*d4q4\$$
 (C121) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C122) $bm1[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C123) $a135:q3*d1q5\$$
 (C124) $a435:ev4ay*drcq5+coel*d4q5\$$
 (C125) $a535:-ev5ay*drcq5+coe*d5q5\$$
 (C126) $bm1[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C127) $rcazt:rc*azt\$$
 (C128) $ev4az:ev4*azt\$$
 (C129) $ev5az:ev5*azt\$$
 (C130) $coel:q4+rcazt\$$
 (C131) $coe:q4-rcazt\$$
 (C132) $a141:q4*d1q1\$$
 (C133) $a441:ev4az*drcq1+coel*d4q1\$$
 (C134) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C135) $bm1[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C136) $a142:q4*d1q2\$$
 (C137) $a442:ev4az*drcq2+coel*d4q2\$$
 (C138) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C139) $bm1[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C140) $a143:q4*d1q3\$$
 (C141) $a443:ev4az*drcq3+coel*d4q3\$$
 (C142) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C143) $bm1[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C144) $a144:q4*d1q4+ev1\$$
 (C145) $a444:ev4+ev4az*drcq4+coel*d4q4\$$
 (C146) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C147) $bm1[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C148) $a145:q4*d1q5\$$
 (C149) $a445:ev4az*drcq5+coel*d4q5\$$
 (C150) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C151) $bm1[4,5]:cg1*a145+cg2*a445+cg3*a545\$$

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(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttg1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bm1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttg2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bm1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttg3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bm1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttg4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bm1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bm1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) sign:1$
(C185) etz:-etz;
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(etx**2+ety**2+etz**2)$
(C189) axt:etx/sada$
(C190) ayt:ety/sada$
(C191) azt:etz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$

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```

(C203) e5:e1-csad$
(C204) ev1:0.0$
(C205) ev4:0.0$
(C206) ev5:0.0$
(C207) cg1:0.0$
(C208) cg2:0.0$
(C209) cg3:0.0$
(C210) d1q1:-ev1*q6$
(C211) d1q2:etx*q6$
(C212) d1q3:ety*q6$
(C213) d1q4:etz*q6$
(C214) d1q5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gmlq6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gmlq6*rqrq*q6$
(C228) depq2:-q2*gmlq6$
(C229) depq3:-q3*gmlq6$
(C230) depq4:-q4*gmlq6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C250) bm2[1,1]:cg2*a411+cg3*a511$
(C251) bm2[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1$
(C252) bm2[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1$

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(C253) $bm2[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$$
 (C254) $bm2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C255) $rcaxt:rc*axt\$$
 (C256) $ev4ax:ev4*axt\$$
 (C257) $ev5ax:ev5*axt\$$
 (C258) $coe1:q2+rcaxt\$$
 (C259) $coe:q2-rcaxt\$$
 (C260) $a121:q2*d1q1\$$
 (C261) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C262) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C263) $bm2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C264) $a122:q2*d1q2+ev1\$$
 (C265) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C266) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C267) $bm2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C268) $a123:q2*d1q3\$$
 (C269) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C270) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C271) $bm2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C272) $a124:q2*d1q4\$$
 (C273) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C274) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C275) $bm2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C276) $a125:q2*d1q5\$$
 (C277) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C278) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C279) $bm2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C280) $rcayt:rc*ayt\$$
 (C281) $ev4ay:ev4*ayt\$$
 (C282) $ev5ay:ev5*ayt\$$
 (C283) $coe1:q3+rcayt\$$
 (C284) $coe:q3-rcayt\$$
 (C285) $a131:q3*d1q1\$$
 (C286) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C287) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C288) $bm2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C289) $a132:q3*d1q2\$$
 (C290) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C291) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C292) $bm2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C293) $a133:q3*d1q3+ev1\$$
 (C294) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C295) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C296) $bm2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C297) $a134:q3*d1q4\$$
 (C298) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C299) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C300) $bm2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C301) $a135:q3*d1q5\$$
 (C302) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C303) $a535:-ev5ay*drcq5+coe*d5q5\$$

(C304) $bm2[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C305) $rcazt:rc*azt\$$
 (C306) $ev4az:ev4*azt\$$
 (C307) $ev5az:ev5*azt\$$
 (C308) $coe1:q4+rcazt\$$
 (C309) $coe:q4-rcazt\$$
 (C310) $a141:q4*d1q1\$$
 (C311) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C312) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C313) $bm2[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C314) $a142:q4*d1q2\$$
 (C315) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C316) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C317) $bm2[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C318) $a143:q4*d1q3\$$
 (C319) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C320) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C321) $bm2[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C322) $a144:q4*d1q4+ev1\$$
 (C323) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C324) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C325) $bm2[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C326) $a145:q4*d1q5\$$
 (C327) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C328) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C329) $bm2[4,5]:cg1*a145+cg2*a445+cg3*a545\$$
 (C330) $rctt:rc*tt\$$
 (C331) $coe:0.5*(q2**2+q3**2+q4**2)*q6\$$
 (C332) $rt:rc*dttq1+tt*drcq1\$$
 (C333) $a151:2*coe*d1q1\$$
 (C334) $a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$$
 (C335) $a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$$
 (C336) $bm2[5,1]:cg1*a151+cg2*a451+cg3*a551\$$
 (C337) $rt:rc*dttq2+tt*drcq2\$$
 (C338) $a152:coe*d1q2-d1q1*q2\$$
 (C339) $a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$$
 (C340) $a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$$
 (C341) $bm2[5,2]:cg1*a152+cg2*a452+cg3*a552\$$
 (C342) $rt:rc*dttq3+tt*drcq3\$$
 (C343) $a153:coe*d1q3-d1q1*q3\$$
 (C344) $a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$$
 (C345) $a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$$
 (C346) $bm2[5,3]:cg1*a153+cg2*a453+cg3*a553\$$
 (C347) $rt:rc*dttq4+tt*drcq4\$$
 (C348) $a154:coe*d1q4-d1q1*q4\$$
 (C349) $a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$$
 (C350) $a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$$
 (C351) $bm2[5,4]:cg1*a154+cg2*a454+cg3*a554\$$
 (C352) $rt:tt*drcq5\$$
 (C353) $a155:coe*d1q5\$$
 (C354) $a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$$

BMSUP

```
(C355) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C356) bm2[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C357) diff:bm1.m-m.bm2$
(C358) diff:ratexpand(diff);
```

```
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
[
[ 0  0  0  0  0 ]
```

(D358)

```
(C359) closefile(Bmsup)$
```



```

(C3) bm1:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C4) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0
,0,0,0,0])$
(C5) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C6) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C7) sign:-1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) etx:0.0$
(C11) sada:sqrt(etx**2+ety**2+etz**2)$
(C12) axt:etx/sada$
(C13) ayt:ety/sada$
(C14) azt:etz/sada$
(C15) rqrq:q2**2+q3**2+q4**2$
(C16) q6:1/q1$
(C17) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C18) prgam:pr*gam$
(C19) pp:q5+pr$
(C20) c:sqrt(prgam*q6)$
(C21) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C22) rc:q1*c$
(C23) csad:c*sada$
(C24) e1:tt*sada$
(C25) e4:e1+csad$
(C26) e5:e1-csad$
(C27) ev1:0.0$
(C28) ev4:0.0$
(C29) ev5:0.5*(e5+sign*abs(e5))$
(C30) cg1:0.0$
(C31) cg2:0.0$
(C32) cg3:cgg2$
(C33) dlq1:-ev1*q6$
(C34) dlq2:etx*q6$
(C35) dlq3:ety*q6$
(C36) dlq4:etz*q6$
(C37) dlq5:0.0$
(C38) coe:gam*(gam-1)/(2*rc)$
(C39) gmlq6:(gam-1)*q6$
(C40) drcq1:coe*q5$
(C41) drcq2:-coe*q2$
(C42) drcq3:-coe*q3$
(C43) drcq4:-coe*q4$
(C44) drcq5:coe*q1$
(C45) dcq1:(drcq1-c)*q6$
(C46) dcq2:drcq2*q6$
(C47) dcq3:drcq3*q6$
(C48) dcq4:drcq4*q6$
(C49) dcq5:drcq5*q6$

```

(C50) depq1:0.5*gmlq6*rqrq*q6\$
 (C51) depq2:-q2*gmlq6\$
 (C52) depq3:-q3*gmlq6\$
 (C53) depq4:-q4*gmlq6\$
 (C54) depq5:gam\$
 (C55) dttq1:-tt*q6\$
 (C56) dttq2:axt*q6\$
 (C57) dttq3:ayt*q6\$
 (C58) dttq4:azt*q6\$
 (C59) dttq5:0.0\$
 (C60) d4q1:sada*(dttq1+dcq1)\$
 (C61) d4q2:sada*(dttq2+dcq2)\$
 (C62) d4q3:sada*(dttq3+dcq3)\$
 (C63) d4q4:sada*(dttq4+dcq4)\$
 (C64) d4q5:sada*dcq5\$
 (C65) d5q1:sada*(dttq1-dcq1)\$
 (C66) d5q2:sada*(dttq2-dcq2)\$
 (C67) d5q3:sada*(dttq3-dcq3)\$
 (C68) d5q4:sada*(dttq4-dcq4)\$
 (C69) d5q5:-d4q5\$
 (C70) a411:ev4+q1*d4q1\$
 (C71) a511:ev5+q1*d5q1\$
 (C72) bm1[1,1]:cg2*a411+cg3*a511\$
 (C73) bm1[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C74) bm1[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C75) bm1[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C76) bm1[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C77) rcaxt:rc*axt\$
 (C78) ev4ax:ev4*axt\$
 (C79) ev5ax:ev5*axt\$
 (C80) coe1:q2+rcaxt\$
 (C81) coe:q2-rcaxt\$
 (C82) a121:q2*d1q1\$
 (C83) a421:ev4ax*drcq1+coe1*d4q1\$
 (C84) a521:-ev5ax*drcq1+coe*d5q1\$
 (C85) bm1[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C86) a122:q2*d1q2+ev1\$
 (C87) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C88) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C89) bm1[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C90) a123:q2*d1q3\$
 (C91) a423:ev4ax*drcq3+coe1*d4q3\$
 (C92) a523:-ev5ax*drcq3+coe*d5q3\$
 (C93) bm1[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C94) a124:q2*d1q4\$
 (C95) a424:ev4ax*drcq4+coe1*d4q4\$
 (C96) a524:-ev5ax*drcq4+coe*d5q4\$
 (C97) bm1[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C98) a125:q2*d1q5\$
 (C99) a425:ev4ax*drcq5+coe1*d4q5\$
 (C100) a525:-ev5ax*drcq5+coe*d5q5\$

(C101) $bm1[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C102) $rcayt:rc*ayt\$$
 (C103) $ev4ay:ev4*ayt\$$
 (C104) $ev5ay:ev5*ayt\$$
 (C105) $coe1:q3+rcayt\$$
 (C106) $coe:q3-rcayt\$$
 (C107) $a131:q3*d1q1\$$
 (C108) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C109) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C110) $bm1[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C111) $a132:q3*d1q2\$$
 (C112) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C113) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C114) $bm1[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C115) $a133:q3*d1q3+ev1\$$
 (C116) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C117) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C118) $bm1[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C119) $a134:q3*d1q4\$$
 (C120) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C121) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C122) $bm1[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C123) $a135:q3*d1q5\$$
 (C124) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C125) $a535:-ev5ay*drcq5+coe*d5q5\$$
 (C126) $bm1[3,5]:cg1*a135+cg2*a435+cg3*a535\$$
 (C127) $rcazt:rc*azt\$$
 (C128) $ev4az:ev4*azt\$$
 (C129) $ev5az:ev5*azt\$$
 (C130) $coe1:q4+rcazt\$$
 (C131) $coe:q4-rcazt\$$
 (C132) $a141:q4*d1q1\$$
 (C133) $a441:ev4az*drcq1+coe1*d4q1\$$
 (C134) $a541:-ev5az*drcq1+coe*d5q1\$$
 (C135) $bm1[4,1]:cg1*a141+cg2*a441+cg3*a541\$$
 (C136) $a142:q4*d1q2\$$
 (C137) $a442:ev4az*drcq2+coe1*d4q2\$$
 (C138) $a542:-ev5az*drcq2+coe*d5q2\$$
 (C139) $bm1[4,2]:cg1*a142+cg2*a442+cg3*a542\$$
 (C140) $a143:q4*d1q3\$$
 (C141) $a443:ev4az*drcq3+coe1*d4q3\$$
 (C142) $a543:-ev5az*drcq3+coe*d5q3\$$
 (C143) $bm1[4,3]:cg1*a143+cg2*a443+cg3*a543\$$
 (C144) $a144:q4*d1q4+ev1\$$
 (C145) $a444:ev4+ev4az*drcq4+coe1*d4q4\$$
 (C146) $a544:ev5-ev5az*drcq4+coe*d5q4\$$
 (C147) $bm1[4,4]:cg1*a144+cg2*a444+cg3*a544\$$
 (C148) $a145:q4*d1q5\$$
 (C149) $a445:ev4az*drcq5+coe1*d4q5\$$
 (C150) $a545:-ev5az*drcq5+coe*d5q5\$$
 (C151) $bm1[4,5]:cg1*a145+cg2*a445+cg3*a545\$$

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(C152) rctt:rc*tt$
(C153) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C154) rt:rc*dttq1+tt*drcq1$
(C155) a151:2*coe*d1q1$
(C156) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C157) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C158) bm1[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C159) rt:rc*dttq2+tt*drcq2$
(C160) a152:coe*d1q2-d1q1*q2$
(C161) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C162) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C163) bm1[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C164) rt:rc*dttq3+tt*drcq3$
(C165) a153:coe*d1q3-d1q1*q3$
(C166) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C167) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C168) bm1[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C169) rt:rc*dttq4+tt*drcq4$
(C170) a154:coe*d1q4-d1q1*q4$
(C171) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C172) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C173) bm1[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C174) rt:tt*drcq5$
(C175) a155:coe*d1q5$
(C176) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C177) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C178) bm1[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C179) q1:q1$
(C180) q2:q2$
(C181) q3:q3$
(C182) q4:-q4$
(C183) q5:q5$
(C184) etz:-etz;
(C185) cggl:(gam-1)/gam$
(C186) cggl2:1/(2*gam)$
(C187) sada:sqrt(etx**2+ety**2+etz**2)$
(C188) axt:etx/sada$
(C189) ayt:ety/sada$
(C190) azt:etz/sada$
(C191) rqrq:q2**2+q3**2+q4**2$
(C192) q6:1/q1$
(C193) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C194) prgam:pr*gam$
(C195) pp:q5+pr$
(C196) c:sqrt(prgam*q6)$
(C197) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C198) rc:q1*c$
(C199) csad:c*sada$
(C200) e1:tt*sada$
(C201) e4:e1+csad$
(C202) e5:e1-csad$

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(C203) ev1:0.0$
(C204) ev4:0.0$
(C205) ev5:0.5*(e5+sign*abs(e5))$
(C206) cg1:0.0$
(C207) cg2:0.0$
(C208) cg3:cgq2$
(C209) dlq1:-ev1*q6$
(C210) dlq2:etx*q6$
(C211) dlq3:ety*q6$
(C212) dlq4:etz*q6$
(C213) dlq5:0.0$
(C214) coe:gam*(gam-1)/(2*rc)$
(C215) gmlq6:(gam-1)*q6$
(C216) drcq1:coe*q5$
(C217) drcq2:-coe*q2$
(C218) drcq3:-coe*q3$
(C219) drcq4:-coe*q4$
(C220) drcq5:coe*q1$
(C221) dcq1:(drcq1-c)*q6$
(C222) dcq2:drcq2*q6$
(C223) dcq3:drcq3*q6$
(C224) dcq4:drcq4*q6$
(C225) dcq5:drcq5*q6$
(C226) depq1:0.5*gmlq6*rqrq*q6$
(C227) depq2:-q2*gmlq6$
(C228) depq3:-q3*gmlq6$
(C229) depq4:-q4*gmlq6$
(C230) depq5:gam$
(C231) dttq1:-tt*q6$
(C232) dttq2:axt*q6$
(C233) dttq3:ayt*q6$
(C234) dttq4:azt*q6$
(C235) dttq5:0.0$
(C236) d4q1:sada*(dttq1+dcq1)$
(C237) d4q2:sada*(dttq2+dcq2)$
(C238) d4q3:sada*(dttq3+dcq3)$
(C239) d4q4:sada*(dttq4+dcq4)$
(C240) d4q5:sada*dcq5$
(C241) d5q1:sada*(dttq1-dcq1)$
(C242) d5q2:sada*(dttq2-dcq2)$
(C243) d5q3:sada*(dttq3-dcq3)$
(C244) d5q4:sada*(dttq4-dcq4)$
(C245) d5q5:-d4q5$
(C246) a411:ev4+q1*d4q1$
(C247) a511:ev5+q1*d5q1$
(C248) bm2:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],
[0,0,0,0,0])$
(C249) bm2[1,1]:cg2*a411+cg3*a511$
(C250) bm2[1,2]:(cg1*dlq2+cg2*d4q2+cg3*d5q2)*q1$
(C251) bm2[1,3]:(cg1*dlq3+cg2*d4q3+cg3*d5q3)*q1$
(C252) bm2[1,4]:(cg1*dlq4+cg2*d4q4+cg3*d5q4)*q1$

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(C253) $bm2[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$$
 (C254) $rcaxt:rc*axt\$$
 (C255) $ev4ax:ev4*axt\$$
 (C256) $ev5ax:ev5*axt\$$
 (C257) $coe1:q2+rcaxt\$$
 (C258) $coe:q2-rcaxt\$$
 (C259) $a121:q2*d1q1\$$
 (C260) $a421:ev4ax*drcq1+coe1*d4q1\$$
 (C261) $a521:-ev5ax*drcq1+coe*d5q1\$$
 (C262) $bm2[2,1]:cg1*a121+cg2*a421+cg3*a521\$$
 (C263) $a122:q2*d1q2+ev1\$$
 (C264) $a422:ev4+ev4ax*drcq2+coe1*d4q2\$$
 (C265) $a522:ev5-ev5ax*drcq2+coe*d5q2\$$
 (C266) $bm2[2,2]:cg1*a122+cg2*a422+cg3*a522\$$
 (C267) $a123:q2*d1q3\$$
 (C268) $a423:ev4ax*drcq3+coe1*d4q3\$$
 (C269) $a523:-ev5ax*drcq3+coe*d5q3\$$
 (C270) $bm2[2,3]:cg1*a123+cg2*a423+cg3*a523\$$
 (C271) $a124:q2*d1q4\$$
 (C272) $a424:ev4ax*drcq4+coe1*d4q4\$$
 (C273) $a524:-ev5ax*drcq4+coe*d5q4\$$
 (C274) $bm2[2,4]:cg1*a124+cg2*a424+cg3*a524\$$
 (C275) $a125:q2*d1q5\$$
 (C276) $a425:ev4ax*drcq5+coe1*d4q5\$$
 (C277) $a525:-ev5ax*drcq5+coe*d5q5\$$
 (C278) $bm2[2,5]:cg1*a125+cg2*a425+cg3*a525\$$
 (C279) $rcayt:rc*ayt\$$
 (C280) $ev4ay:ev4*ayt\$$
 (C281) $ev5ay:ev5*ayt\$$
 (C282) $coe1:q3+rcayt\$$
 (C283) $coe:q3-rcayt\$$
 (C284) $a131:q3*d1q1\$$
 (C285) $a431:ev4ay*drcq1+coe1*d4q1\$$
 (C286) $a531:-ev5ay*drcq1+coe*d5q1\$$
 (C287) $bm2[3,1]:cg1*a131+cg2*a431+cg3*a531\$$
 (C288) $a132:q3*d1q2\$$
 (C289) $a432:ev4ay*drcq2+coe1*d4q2\$$
 (C290) $a532:-ev5ay*drcq2+coe*d5q2\$$
 (C291) $bm2[3,2]:cg1*a132+cg2*a432+cg3*a532\$$
 (C292) $a133:q3*d1q3+ev1\$$
 (C293) $a433:ev4+ev4ay*drcq3+coe1*d4q3\$$
 (C294) $a533:ev5-ev5ay*drcq3+coe*d5q3\$$
 (C295) $bm2[3,3]:cg1*a133+cg2*a433+cg3*a533\$$
 (C296) $a134:q3*d1q4\$$
 (C297) $a434:ev4ay*drcq4+coe1*d4q4\$$
 (C298) $a534:-ev5ay*drcq4+coe*d5q4\$$
 (C299) $bm2[3,4]:cg1*a134+cg2*a434+cg3*a534\$$
 (C300) $a135:q3*d1q5\$$
 (C301) $a435:ev4ay*drcq5+coe1*d4q5\$$
 (C302) $a535:-ev5ay*drcq5+coe*d5q5\$$
 (C303) $bm2[3,5]:cg1*a135+cg2*a435+cg3*a535\$$

(C304) rcazt:rc*azt\$
 (C305) ev4az:ev4*azt\$
 (C306) ev5az:ev5*azt\$
 (C307) coe1:q4+rcazt\$
 (C308) coe:q4-rcazt\$
 (C309) a141:q4*d1q1\$
 (C310) a441:ev4az*drcq1+coe1*d4q1\$
 (C311) a541:-ev5az*drcq1+coe*d5q1\$
 (C312) bm2[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C313) a142:q4*d1q2\$
 (C314) a442:ev4az*drcq2+coe1*d4q2\$
 (C315) a542:-ev5az*drcq2+coe*d5q2\$
 (C316) bm2[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C317) a143:q4*d1q3\$
 (C318) a443:ev4az*drcq3+coe1*d4q3\$
 (C319) a543:-ev5az*drcq3+coe*d5q3\$
 (C320) bm2[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C321) a144:q4*d1q4+ev1\$
 (C322) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C323) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C324) bm2[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C325) a145:q4*d1q5\$
 (C326) a445:ev4az*drcq5+coe1*d4q5\$
 (C327) a545:-ev5az*drcq5+coe*d5q5\$
 (C328) bm2[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C329) rctt:rc*tt\$
 (C330) coe:0.5*(q2**2+q3**2+q4**2)*q6\$
 (C331) rt:rc*dttq1+tt*drcq1\$
 (C332) a151:2*coe*d1q1\$
 (C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$
 (C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$
 (C335) bm2[5,1]:cg1*a151+cg2*a451+cg3*a551\$
 (C336) rt:rc*dttq2+tt*drcq2\$
 (C337) a152:coe*d1q2-d1q1*q2\$
 (C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$
 (C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$
 (C340) bm2[5,2]:cg1*a152+cg2*a452+cg3*a552\$
 (C341) rt:rc*dttq3+tt*drcq3\$
 (C342) a153:coe*d1q3-d1q1*q3\$
 (C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$
 (C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$
 (C345) bm2[5,3]:cg1*a153+cg2*a453+cg3*a553\$
 (C346) rt:rc*dttq4+tt*drcq4\$
 (C347) a154:coe*d1q4-d1q1*q4\$
 (C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$
 (C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$
 (C350) bm2[5,4]:cg1*a154+cg2*a454+cg3*a554\$
 (C351) rt:tt*drcq5\$
 (C352) a155:coe*d1q5\$
 (C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$
 (C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$

BMSUB

(C355) bm2[5,5]:cg1*a155+cg2*a455+cg3*a555\$

(C356) diff:bm1.m-m.bm2\$

(C357) diff:ratexpand(diff);

```
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]
```

(D357)

(C358) closefile(Bmsub)\$

■

```

(C3) cp:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C4) cm:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C11) axt:ztx/sada$
(C12) ayt:zty/sada$
(C13) azt:ztz/sada$
(C14) rqrq:q2**2+q3**2+q4**2$
(C15) q6:1/q1$
(C16) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17) prgam:pr*gam$
(C18) pp:q5+pr$
(C19) c:sqrt(prgam*q6)$
(C20) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21) rc:q1*c$
(C22) csad:c*sada$
(C23) e1:tt*sada$
(C24) e4:e1+csad$
(C25) e5:e1-csad$
(C26) ev1:e1$
(C27) ev4:e4$
(C28) ev5:e1$
(C29) cg1:cgg1$
(C30) cg2:cgg2$
(C31) cg3:cgg2$
(C32) d1q1:-ev1*q6$
(C33) d1q2:ztx*q6$
(C34) d1q3:zty*q6$
(C35) d1q4:ztz*q6$
(C36) d1q5:0.0$
(C37) coe:gam*(gam-1)/(2*rc)$
(C38) gmlq6:(gam-1)*q6$
(C39) drcq1:coe*q5$
(C40) drcq2:-coe*q2$
(C41) drcq3:-coe*q3$
(C42) drcq4:-coe*q4$
(C43) drcq5:coe*q1$
(C44) dcq1:(drcq1-c)*q6$
(C45) dcq2:drcq2*q6$
(C46) dcq3:drcq3*q6$
(C47) dcq4:drcq4*q6$
(C48) dcq5:drcq5*q6$
(C49) depq1:0.5*gmlq6*rqrq*q6$

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(C50) depq2:-q2*gm1q6\$
 (C51) depq3:-q3*gm1q6\$
 (C52) depq4:-q4*gm1q6\$
 (C53) depq5:gam\$
 (C54) dttq1:-tt*q6\$
 (C55) dttq2:axt*q6\$
 (C56) dttq3:ayt*q6\$
 (C57) dttq4:azt*q6\$
 (C58) dttq5:0.0\$
 (C59) d4q1:sada*(dttq1+dcq1)\$
 (C60) d4q2:sada*(dttq2+dcq2)\$
 (C61) d4q3:sada*(dttq3+dcq3)\$
 (C62) d4q4:sada*(dttq4+dcq4)\$
 (C63) d4q5:sada*dcq5\$
 (C64) d5q1:sada*(dttq1-dcq1)\$
 (C65) d5q2:sada*(dttq2-dcq2)\$
 (C66) d5q3:sada*(dttq3-dcq3)\$
 (C67) d5q4:sada*(dttq4-dcq4)\$
 (C68) d5q5:-d4q5\$
 (C69) a411:ev4+q1*d4q1\$
 (C70) a511:ev5+q1*d5q1\$
 (C71) cp[1,1]:cg2*a411+cg3*a511\$
 (C72) cp[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C73) cp[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C74) cp[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C75) cp[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C76) rcaxt:rc*axt\$
 (C77) ev4ax:ev4*axt\$
 (C78) ev5ax:ev5*axt\$
 (C79) coe1:q2+rcaxt\$
 (C80) coe:q2-rcaxt\$
 (C81) a121:q2*d1q1\$
 (C82) a421:ev4ax*drcq1+coe1*d4q1\$
 (C83) a521:-ev5ax*drcq1+coe*d5q1\$
 (C84) cp[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C85) a122:q2*d1q2+ev1\$
 (C86) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C87) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C88) cp[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C89) a123:q2*d1q3\$
 (C90) a423:ev4ax*drcq3+coe1*d4q3\$
 (C91) a523:-ev5ax*drcq3+coe*d5q3\$
 (C92) cp[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C93) a124:q2*d1q4\$
 (C94) a424:ev4ax*drcq4+coe1*d4q4\$
 (C95) a524:-ev5ax*drcq4+coe*d5q4\$
 (C96) cp[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C97) a125:q2*d1q5\$
 (C98) a425:ev4ax*drcq5+coe1*d4q5\$
 (C99) a525:-ev5ax*drcq5+coe*d5q5\$
 (C100) cp[2,5]:cg1*a125+cg2*a425+cg3*a525\$

(C101) rcayt:rc*ayt\$
 (C102) ev4ay:ev4*ayt\$
 (C103) ev5ay:ev5*ayt\$
 (C104) coe1:q3+rcayt\$
 (C105) coe:q3-rcayt\$
 (C106) a131:q3*d1q1\$
 (C107) a431:ev4ay*drcq1+coe1*d4q1\$
 (C108) a531:-ev5ay*drcq1+coe*d5q1\$
 (C109) cp[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C110) a132:q3*d1q2\$
 (C111) a432:ev4ay*drcq2+coe1*d4q2\$
 (C112) a532:-ev5ay*drcq2+coe*d5q2\$
 (C113) cp[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C114) a133:q3*d1q3+ev1\$
 (C115) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C116) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C117) cp[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C118) a134:q3*d1q4\$
 (C119) a434:ev4ay*drcq4+coe1*d4q4\$
 (C120) a534:-ev5ay*drcq4+coe*d5q4\$
 (C121) cp[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C122) a135:q3*d1q5\$
 (C123) a435:ev4ay*drcq5+coe1*d4q5\$
 (C124) a535:-ev5ay*drcq5+coe*d5q5\$
 (C125) cp[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C126) rcazt:rc*azt\$
 (C127) ev4az:ev4*azt\$
 (C128) ev5az:ev5*azt\$
 (C129) coe1:q4+rcazt\$
 (C130) coe:q4-rcazt\$
 (C131) a141:q4*d1q1\$
 (C132) a441:ev4az*drcq1+coe1*d4q1\$
 (C133) a541:-ev5az*drcq1+coe*d5q1\$
 (C134) cp[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C135) a142:q4*d1q2\$
 (C136) a442:ev4az*drcq2+coe1*d4q2\$
 (C137) a542:-ev5az*drcq2+coe*d5q2\$
 (C138) cp[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C139) a143:q4*d1q3\$
 (C140) a443:ev4az*drcq3+coe1*d4q3\$
 (C141) a543:-ev5az*drcq3+coe*d5q3\$
 (C142) cp[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C143) a144:q4*d1q4+ev1\$
 (C144) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C145) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C146) cp[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C147) a145:q4*d1q5\$
 (C148) a445:ev4az*drcq5+coe1*d4q5\$
 (C149) a545:-ev5az*drcq5+coe*d5q5\$
 (C150) cp[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C151) rctt:rc*tt\$

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(C152) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C153) rt:rc*dttq1+tt*drcq1$
(C154) a151:2*coe*d1q1$
(C155) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C156) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C157) cp[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C158) rt:rc*dttq2+tt*drcq2$
(C159) a152:coe*d1q2-d1q1*q2$
(C160) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C161) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C162) cp[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C163) rt:rc*dttq3+tt*drcq3$
(C164) a153:coe*d1q3-d1q1*q3$
(C165) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C166) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C167) cp[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C168) rt:rc*dttq4+tt*drcq4$
(C169) a154:coe*d1q4-d1q1*q4$
(C170) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C171) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C172) cp[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C173) rt:tt*drcq5$
(C174) a155:coe*d1q5$
(C175) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C176) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C177) cp[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C178) q1:q1$
(C179) q2:q2$
(C180) q3:q3$
(C181) q4:-q4$
(C182) q5:q5$
(C183) ztx:-ztx$
(C184) zty:-zty$
(C185) sign:-1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C189) axt:ztx/sada$
(C190) ayt:zty/sada$
(C191) azt:ztz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$

```

```

(C203) e5:e1-csad$
(C204) ev1:e1$
(C205) ev4:e1$
(C206) ev5:e5$
(C209) cg1:cg1$
(C208) cg2:cg2$
(C209) cg3:cg2$
(C210) dlq1:-ev1*q6$
(C211) dlq2:ztx*q6$
(C212) dlq3:zty*q6$
(C213) dlq4:ztz*q6$
(C214) dlq5:0.0$
(C215) coe:gam*(gam-1)/(2*rc)$
(C216) gmlq6:(gam-1)*q6$
(C217) drcq1:coe*q5$
(C218) drcq2:-coe*q2$
(C219) drcq3:-coe*q3$
(C220) drcq4:-coe*q4$
(C221) drcq5:coe*q1$
(C222) dcq1:(drcq1-c)*q6$
(C223) dcq2:drcq2*q6$
(C224) dcq3:drcq3*q6$
(C225) dcq4:drcq4*q6$
(C226) dcq5:drcq5*q6$
(C227) depq1:0.5*gmlq6*rqrq*q6$
(C228) depq2:-q2*gmlq6$
(C229) depq3:-q3*gmlq6$
(C230) depq4:-q4*gmlq6$
(C231) depq5:gam$
(C232) dttq1:-tt*q6$
(C233) dttq2:axt*q6$
(C234) dttq3:ayt*q6$
(C235) dttq4:azt*q6$
(C236) dttq5:0.0$
(C237) d4q1:sada*(dttq1+dcq1)$
(C238) d4q2:sada*(dttq2+dcq2)$
(C239) d4q3:sada*(dttq3+dcq3)$
(C240) d4q4:sada*(dttq4+dcq4)$
(C241) d4q5:sada*dcq5$
(C242) d5q1:sada*(dttq1-dcq1)$
(C243) d5q2:sada*(dttq2-dcq2)$
(C244) d5q3:sada*(dttq3-dcq3)$
(C245) d5q4:sada*(dttq4-dcq4)$
(C246) d5q5:-d4q5$
(C247) a411:ev4+q1*d4q1$
(C248) a511:ev5+q1*d5q1$
(C249) cm[1,1]:cg2*a411+cg3*a511$
(C250) cm[1,2]:(cg1*dlq2+cg2*d4q2+cg3*d5q2)*q1$
(C251) cm[1,3]:(cg1*dlq3+cg2*d4q3+cg3*d5q3)*q1$
(C252) cm[1,4]:(cg1*dlq4+cg2*d4q4+cg3*d5q4)*q1$
(C253) cm[1,5]:(cg2*d4q5+cg3*d5q5)*q1$

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(C254) rcaxt:rc*axt\$
 (C255) ev4ax:ev4*axt\$
 (C256) ev5ax:ev5*axt\$
 (C257) coe1:q2+rcaxt\$
 (C258) coe:q2-rcaxt\$
 (C259) a121:q2*d1q1\$
 (C260) a421:ev4ax*drcq1+coe1*d4q1\$
 (C261) a521:-ev5ax*drcq1+coe*d5q1\$
 (C262) cm[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C263) a122:q2*d1q2+ev1\$
 (C264) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C265) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C266) cm[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C267) a123:q2*d1q3\$
 (C268) a423:ev4ax*drcq3+coe1*d4q3\$
 (C269) a523:-ev5ax*drcq3+coe*d5q3\$
 (C270) cm[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C271) a124:q2*d1q4\$
 (C272) a424:ev4ax*drcq4+coe1*d4q4\$
 (C273) a524:-ev5ax*drcq4+coe*d5q4\$
 (C274) cm[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C275) a125:q2*d1q5\$
 (C276) a425:ev4ax*drcq5+coe1*d4q5\$
 (C277) a525:-ev5ax*drcq5+coe*d5q5\$
 (C278) cm[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C279) rcayt:rc*ayt\$
 (C280) ev4ay:ev4*ayt\$
 (C281) ev5ay:ev5*ayt\$
 (C282) coe1:q3+rcayt\$
 (C283) coe:q3-rcayt\$
 (C284) a131:q3*d1q1\$
 (C285) a431:ev4ay*drcq1+coe1*d4q1\$
 (C286) a531:-ev5ay*drcq1+coe*d5q1\$
 (C287) cm[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C288) a132:q3*d1q2\$
 (C289) a432:ev4ay*drcq2+coe1*d4q2\$
 (C290) a532:-ev5ay*drcq2+coe*d5q2\$
 (C291) cm[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C292) a133:q3*d1q3+ev1\$
 (C293) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C294) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C295) cm[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C296) a134:q3*d1q4\$
 (C297) a434:ev4ay*drcq4+coe1*d4q4\$
 (C298) a534:-ev5ay*drcq4+coe*d5q4\$
 (C299) cm[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C300) a135:q3*d1q5\$
 (C301) a435:ev4ay*drcq5+coe1*d4q5\$
 (C302) a535:-ev5ay*drcq5+coe*d5q5\$
 (C303) cm[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C304) rcagt:rc*agt\$

(C305) ev4az:ev4*azt\$
 (C306) ev5az:ev5*azt\$
 (C307) coel:q4+rcazt\$
 (C308) coe:q4-rcazt\$
 (C309) a141:q4*d1q1\$
 (C310) a441:ev4az*drcq1+coel*d4q1\$
 (C311) a541:-ev5az*drcq1+coe*d5q1\$
 (C312) cm[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C313) a142:q4*d1q2\$
 (C314) a442:ev4az*drcq2+coel*d4q2\$
 (C315) a542:-ev5az*drcq2+coe*d5q2\$
 (C316) cm[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C317) a143:q4*d1q3\$
 (C318) a443:ev4az*drcq3+coel*d4q3\$
 (C319) a543:-ev5az*drcq3+coe*d5q3\$
 (C320) cm[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C321) a144:q4*d1q4+ev1\$
 (C322) a444:ev4+ev4az*drcq4+coel*d4q4\$
 (C323) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C324) cm[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C325) a145:q4*d1q5\$
 (C326) a445:ev4az*drcq5+coel*d4q5\$
 (C327) a545:-ev5az*drcq5+coe*d5q5\$
 (C328) cm[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C329) rctt:rc*tt\$
 (C330) coe:0.5*(q2**2+q3**2+q4**2)*q6\$
 (C331) rt:rc*dttq1+tt*drcq1\$
 (C332) a151:2*coe*d1q1\$
 (C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$
 (C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$
 (C335) cm[5,1]:cg1*a151+cg2*a451+cg3*a551\$
 (C336) rt:rc*dttq2+tt*drcq2\$
 (C337) a152:coe*d1q2-d1q1*q2\$
 (C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$
 (C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$
 (C340) cm[5,2]:cg1*a152+cg2*a452+cg3*a552\$
 (C341) rt:rc*dttq3+tt*drcq3\$
 (C342) a153:coe*d1q3-d1q1*q3\$
 (C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$
 (C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$
 (C346) rt:rc*dttq4+tt*drcq4\$
 (C347) a154:coe*d1q4-d1q1*q4\$
 (C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$
 (C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$
 (C350) cm[5,4]:cg1*a154+cg2*a454+cg3*a554\$
 (C351) rt:tt*drcq5\$
 (C352) a155:coe*d1q5\$
 (C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$
 (C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$
 (C355) cm[5,5]:cg1*a155+cg2*a455+cg3*a555\$
 (C356) diff:cp.m+m.cm\$

```
(C357) diff:ratexpand(diff);
```

```
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]  
[  
[ 0  0  0  0  0 ]
```

```
(D357)
```

```
(C358) closefile(Ccsup1)$
```

```
■
```

```

(C3) cp:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C4) cm:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,
0,0,0,0])$
(C5) diff:matrix([0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[0,0,0,0,0],[
0,0,0,0,0])$
(C6) m:matrix([1,0,0,0,0],[0,1,0,0,0],[0,0,1,0,0],[0,0,0,-1,0],[0,
0,0,0,1])$
(C7) sign:1$
(C8) cgg1:(gam-1)/gam$
(C9) cgg2:1/(2*gam)$
(C10) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C11) axt:ztx/sada$
(C12) ayt:zty/sada$
(C13) azt:ztz/sada$
(C14) rqrq:q2**2+q3**2+q4**2$
(C15) q6:1/q1$
(C16) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C17) prgam:pr*gam$
(C18) pp:q5+pr$
(C19) c:sqrt(prgam*q6)$
(C20) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C21) rc:q1*c$
(C22) csad:c*sada$
(C23) e1:tt*sada$
(C24) e4:e1+csad$
(C25) e5:e1-csad$
(C26) ev1:e1$
(C27) ev4:e4$
(C28) ev5:0.0$
(C29) cg1:cgg1$
(C30) cg2:cgg2$
(C31) cg3:0.0$
(C32) dlq1:-ev1*q6$
(C33) dlq2:ztx*q6$
(C34) dlq3:zty*q6$
(C35) dlq4:ztz*q6$
(C36) dlq5:0.0$
(C37) coe:gam*(gam-1)/(2*rc)$
(C38) gmlq6:(gam-1)*q6$
(C39) drcq1:coe*q5$
(C40) drcq2:-coe*q2$
(C41) drcq3:-coe*q3$
(C42) drcq4:-coe*q4$
(C43) drcq5:coe*q1$
(C44) dcq1:(drcq1-c)*q6$
(C45) dcq2:drcq2*q6$
(C46) dcq3:drcq3*q6$
(C47) dcq4:drcq4*q6$
(C48) dcq5:drcq5*q6$
(C49) depq1:0.5*gmlq6*rqrq*q6$

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(C50) depq2:-q2*gm1q6\$
 (C51) depq3:-q3*gm1q6\$
 (C52) depq4:-q4*gm1q6\$
 (C53) depq5:gam\$
 (C54) dttq1:-tt*q6\$
 (C55) dttq2:axt*q6\$
 (C56) dttq3:ayt*q6\$
 (C57) dttq4:azt*q6\$
 (C58) dttq5:0.0\$
 (C59) d4q1:sada*(dttq1+dcq1)\$
 (C60) d4q2:sada*(dttq2+dcq2)\$
 (C61) d4q3:sada*(dttq3+dcq3)\$
 (C62) d4q4:sada*(dttq4+dcq4)\$
 (C63) d4q5:sada*dcq5\$
 (C64) d5q1:sada*(dttq1-dcq1)\$
 (C65) d5q2:sada*(dttq2-dcq2)\$
 (C66) d5q3:sada*(dttq3-dcq3)\$
 (C67) d5q4:sada*(dttq4-dcq4)\$
 (C68) d5q5:-d4q5\$
 (C69) a411:ev4+q1*d4q1\$
 (C70) a511:ev5+q1*d5q1\$
 (C71) cp[1,1]:cg2*a411+cg3*a511\$
 (C72) cp[1,2]:(cg1*d1q2+cg2*d4q2+cg3*d5q2)*q1\$
 (C73) cp[1,3]:(cg1*d1q3+cg2*d4q3+cg3*d5q3)*q1\$
 (C74) cp[1,4]:(cg1*d1q4+cg2*d4q4+cg3*d5q4)*q1\$
 (C75) cp[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$
 (C76) rcaxt:rc*axt\$
 (C77) ev4ax:ev4*axt\$
 (C78) ev5ax:ev5*axt\$
 (C79) coe1:q2+rcaxt\$
 (C80) coe:q2-rcaxt\$
 (C81) a121:q2*d1q1\$
 (C82) a421:ev4ax*drcq1+coe1*d4q1\$
 (C83) a521:-ev5ax*drcq1+coe*d5q1\$
 (C84) cp[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C85) a122:q2*d1q2+ev1\$
 (C86) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C87) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C88) cp[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C89) a123:q2*d1q3\$
 (C90) a423:ev4ax*drcq3+coe1*d4q3\$
 (C91) a523:-ev5ax*drcq3+coe*d5q3\$
 (C92) cp[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C93) a124:q2*d1q4\$
 (C94) a424:ev4ax*drcq4+coe1*d4q4\$
 (C95) a524:-ev5ax*drcq4+coe*d5q4\$
 (C96) cp[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C97) a125:q2*d1q5\$
 (C98) a425:ev4ax*drcq5+coe1*d4q5\$
 (C99) a525:-ev5ax*drcq5+coe*d5q5\$
 (C100) cp[2,5]:cg1*a125+cg2*a425+cg3*a525\$

(C101) rcayt:rc*ayt\$
 (C102) ev4ay:ev4*ayt\$
 (C103) ev5ay:ev5*ayt\$
 (C104) coe1:q3+rcayt\$
 (C105) coe:q3-rcayt\$
 (C106) a131:q3*d1q1\$
 (C107) a431:ev4ay*drcq1+coe1*d4q1\$
 (C108) a531:-ev5ay*drcq1+coe*d5q1\$
 (C109) cp[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C110) a132:q3*d1q2\$
 (C111) a432:ev4ay*drcq2+coe1*d4q2\$
 (C112) a532:-ev5ay*drcq2+coe*d5q2\$
 (C113) cp[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C114) a133:q3*d1q3+ev1\$
 (C115) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C116) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C117) cp[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C118) a134:q3*d1q4\$
 (C119) a434:ev4ay*drcq4+coe1*d4q4\$
 (C120) a534:-ev5ay*drcq4+coe*d5q4\$
 (C121) cp[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C122) a135:q3*d1q5\$
 (C123) a435:ev4ay*drcq5+coe1*d4q5\$
 (C124) a535:-ev5ay*drcq5+coe*d5q5\$
 (C125) cp[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C126) rcazt:rc*azt\$
 (C127) ev4az:ev4*azt\$
 (C128) ev5az:ev5*azt\$
 (C129) coe1:q4+rcazt\$
 (C130) coe:q4-rcazt\$
 (C131) a141:q4*d1q1\$
 (C132) a441:ev4az*drcq1+coe1*d4q1\$
 (C133) a541:-ev5az*drcq1+coe*d5q1\$
 (C134) cp[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C135) a142:q4*d1q2\$
 (C136) a442:ev4az*drcq2+coe1*d4q2\$
 (C137) a542:-ev5az*drcq2+coe*d5q2\$
 (C138) cp[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C139) a143:q4*d1q3\$
 (C140) a443:ev4az*drcq3+coe1*d4q3\$
 (C141) a543:-ev5az*drcq3+coe*d5q3\$
 (C142) cp[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C143) a144:q4*d1q4+ev1\$
 (C144) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C145) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C146) cp[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C147) a145:q4*d1q5\$
 (C148) a445:ev4az*drcq5+coe1*d4q5\$
 (C149) a545:-ev5az*drcq5+coe*d5q5\$
 (C150) cp[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C151) rctt:rc*tt\$

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(C152) coe:0.5*(q2**2+q3**2+q4**2)*q6$
(C153) rt:rc*dttq1+tt*drcq1$
(C154) a151:2*coe*d1q1$
(C155) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1$
(C156) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1$
(C157) cp[5,1]:cg1*a151+cg2*a451+cg3*a551$
(C158) rt:rc*dttq2+tt*drcq2$
(C159) a152:coe*d1q2-d1q1*q2$
(C160) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2$
(C161) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2$
(C162) cp[5,2]:cg1*a152+cg2*a452+cg3*a552$
(C163) rt:rc*dttq3+tt*drcq3$
(C164) a153:coe*d1q3-d1q1*q3$
(C165) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3$
(C166) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3$
(C167) cp[5,3]:cg1*a153+cg2*a453+cg3*a553$
(C168) rt:rc*dttq4+tt*drcq4$
(C169) a154:coe*d1q4-d1q1*q4$
(C170) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4$
(C171) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4$
(C172) cp[5,4]:cg1*a154+cg2*a454+cg3*a554$
(C173) rt:tt*drcq5$
(C174) a155:coe*d1q5$
(C175) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5$
(C176) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5$
(C177) cp[5,5]:cg1*a155+cg2*a455+cg3*a555$
(C178) q1:q1$
(C179) q2:q2$
(C180) q3:q3$
(C181) q4:-q4$
(C182) q5:q5$
(C183) ztx:-ztx$
(C184) zty:-zty$
(C185) sign:-1$
(C186) cgg1:(gam-1)/gam$
(C187) cgg2:1/(2*gam)$
(C188) sada:sqrt(ztx**2+zty**2+ztz**2)$
(C189) axt:ztx/sada$
(C190) ayt:zty/sada$
(C191) azt:ztz/sada$
(C192) rqrq:q2**2+q3**2+q4**2$
(C193) q6:1/q1$
(C194) pr:(gam-1)*(q5-0.5*rqrq*q6)$
(C195) prgam:pr*gam$
(C196) pp:q5+pr$
(C197) c:sqrt(prgam*q6)$
(C198) tt:(q2*axt+q3*ayt+q4*azt)*q6$
(C199) rc:q1*c$
(C200) csad:c*sada$
(C201) e1:tt*sada$
(C202) e4:e1+csad$

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(C203) e5:e1-csad\$
 (C204) ev1:e1\$
 (C205) ev4:0.0\$
 (C206) ev5:e5\$
 (C207) cg1:cg1\$
 (C208) cg2:0.0\$
 (C209) cg3:cg2\$
 (C210) dlq1:-ev1*q6\$
 (C211) dlq2:ztx*q6\$
 (C212) dlq3:zty*q6\$
 (C213) dlq4:ztz*q6\$
 (C214) dlq5:0.0\$
 (C215) coe:gam*(gam-1)/(2*rc)\$
 (C216) gm1q6:(gam-1)*q6\$
 (C217) drcq1:coe*q5\$
 (C218) drcq2:-coe*q2\$
 (C219) drcq3:-coe*q3\$
 (C220) drcq4:-coe*q4\$
 (C221) drcq5:coe*q1\$
 (C222) dcq1:(drcq1-c)*q6\$
 (C223) dcq2:drcq2*q6\$
 (C224) dcq3:drcq3*q6\$
 (C225) dcq4:drcq4*q6\$
 (C226) dcq5:drcq5*q6\$
 (C227) depq1:0.5*gm1q6*rqrq*q6\$
 (C228) depq2:-q2*gm1q6\$
 (C229) depq3:-q3*gm1q6\$
 (C230) depq4:-q4*gm1q6\$
 (C231) depq5:gam\$
 (C232) dttq1:-tt*q6\$
 (C233) dttq2:axt*q6\$
 (C234) dttq3:ayt*q6\$
 (C235) dttq4:azt*q6\$
 (C236) dttq5:0.0\$
 (C237) d4q1:sada*(dttq1+dcq1)\$
 (C238) d4q2:sada*(dttq2+dcq2)\$
 (C239) d4q3:sada*(dttq3+dcq3)\$
 (C240) d4q4:sada*(dttq4+dcq4)\$
 (C241) d4q5:sada*dcq5\$
 (C242) d5q1:sada*(dttq1-dcq1)\$
 (C243) d5q2:sada*(dttq2-dcq2)\$
 (C244) d5q3:sada*(dttq3-dcq3)\$
 (C245) d5q4:sada*(dttq4-dcq4)\$
 (C246) d5q5:-d4q5\$
 (C247) a411:ev4+q1*d4q1\$
 (C248) a511:ev5+q1*d5q1\$
 (C249) cm[1,1]:cg2*a411+cg3*a511\$
 (C250) cm[1,2]:(cg1*dlq2+cg2*d4q2+cg3*d5q2)*q1\$
 (C251) cm[1,3]:(cg1*dlq3+cg2*d4q3+cg3*d5q3)*q1\$
 (C252) cm[1,4]:(cg1*dlq4+cg2*d4q4+cg3*d5q4)*q1\$
 (C253) cm[1,5]:(cg2*d4q5+cg3*d5q5)*q1\$

(C254) rcaxt:rc*axt\$
 (C255) ev4ax:ev4*axt\$
 (C256) ev5ax:ev5*axt\$
 (C257) coe1:q2+rcaxt\$
 (C258) coe:q2-rcaxt\$
 (C259) a121:q2*d1q1\$
 (C260) a421:ev4ax*drcq1+coe1*d4q1\$
 (C261) a521:-ev5ax*drcq1+coe*d5q1\$
 (C262) cm[2,1]:cg1*a121+cg2*a421+cg3*a521\$
 (C263) a122:q2*d1q2+ev1\$
 (C264) a422:ev4+ev4ax*drcq2+coe1*d4q2\$
 (C265) a522:ev5-ev5ax*drcq2+coe*d5q2\$
 (C266) cm[2,2]:cg1*a122+cg2*a422+cg3*a522\$
 (C267) a123:q2*d1q3\$
 (C268) a423:ev4ax*drcq3+coe1*d4q3\$
 (C269) a523:-ev5ax*drcq3+coe*d5q3\$
 (C270) cm[2,3]:cg1*a123+cg2*a423+cg3*a523\$
 (C271) a124:q2*d1q4\$
 (C272) a424:ev4ax*drcq4+coe1*d4q4\$
 (C273) a524:-ev5ax*drcq4+coe*d5q4\$
 (C274) cm[2,4]:cg1*a124+cg2*a424+cg3*a524\$
 (C275) a125:q2*d1q5\$
 (C276) a425:ev4ax*drcq5+coe1*d4q5\$
 (C277) a525:-ev5ax*drcq5+coe*d5q5\$
 (C278) cm[2,5]:cg1*a125+cg2*a425+cg3*a525\$
 (C279) rcayt:rc*ayt\$
 (C280) ev4ay:ev4*ayt\$
 (C281) ev5ay:ev5*ayt\$
 (C282) coe1:q3+rcayt\$
 (C283) coe:q3-rcayt\$
 (C284) a131:q3*d1q1\$
 (C285) a431:ev4ay*drcq1+coe1*d4q1\$
 (C286) a531:-ev5ay*drcq1+coe*d5q1\$
 (C287) cm[3,1]:cg1*a131+cg2*a431+cg3*a531\$
 (C288) a132:q3*d1q2\$
 (C289) a432:ev4ay*drcq2+coe1*d4q2\$
 (C290) a532:-ev5ay*drcq2+coe*d5q2\$
 (C291) cm[3,2]:cg1*a132+cg2*a432+cg3*a532\$
 (C292) a133:q3*d1q3+ev1\$
 (C293) a433:ev4+ev4ay*drcq3+coe1*d4q3\$
 (C294) a533:ev5-ev5ay*drcq3+coe*d5q3\$
 (C295) cm[3,3]:cg1*a133+cg2*a433+cg3*a533\$
 (C296) a134:q3*d1q4\$
 (C297) a434:ev4ay*drcq4+coe1*d4q4\$
 (C298) a534:-ev5ay*drcq4+coe*d5q4\$
 (C299) cm[3,4]:cg1*a134+cg2*a434+cg3*a534\$
 (C300) a135:q3*d1q5\$
 (C301) a435:ev4ay*drcq5+coe1*d4q5\$
 (C302) a535:-ev5ay*drcq5+coe*d5q5\$
 (C303) cm[3,5]:cg1*a135+cg2*a435+cg3*a535\$
 (C304) rcagt:rc*agt\$

(C305) ev4az:ev4*azt\$
 (C306) ev5az:ev5*azt\$
 (C307) coe1:q4+rcazt\$
 (C308) coe:q4-rcazt\$
 (C309) a141:q4*d1q1\$
 (C310) a441:ev4az*drcq1+coe1*d4q1\$
 (C311) a541:-ev5az*drcq1+coe*d5q1\$
 (C312) cm[4,1]:cg1*a141+cg2*a441+cg3*a541\$
 (C313) a142:q4*d1q2\$
 (C314) a442:ev4az*drcq2+coe1*d4q2\$
 (C315) a542:-ev5az*drcq2+coe*d5q2\$
 (C316) cm[4,2]:cg1*a142+cg2*a442+cg3*a542\$
 (C317) a143:q4*d1q3\$
 (C318) a443:ev4az*drcq3+coe1*d4q3\$
 (C319) a543:-ev5az*drcq3+coe*d5q3\$
 (C320) cm[4,3]:cg1*a143+cg2*a443+cg3*a543\$
 (C321) a144:q4*d1q4+ev1\$
 (C322) a444:ev4+ev4az*drcq4+coe1*d4q4\$
 (C323) a544:ev5-ev5az*drcq4+coe*d5q4\$
 (C324) cm[4,4]:cg1*a144+cg2*a444+cg3*a544\$
 (C325) a145:q4*d1q5\$
 (C326) a445:ev4az*drcq5+coe1*d4q5\$
 (C327) a545:-ev5az*drcq5+coe*d5q5\$
 (C328) cm[4,5]:cg1*a145+cg2*a445+cg3*a545\$
 (C329) rctt:rc*tt\$
 (C330) coe:0.5*(q2**2+q3**2+q4**2)*q6\$
 (C331) rt:rc*dttq1+tt*drcq1\$
 (C332) a151:2*coe*d1q1\$
 (C333) a451:ev4*(depq1+rt)+(pp+rctt)*d4q1\$
 (C334) a551:ev5*(depq1-rt)+(pp-rctt)*d5q1\$
 (C335) cm[5,1]:cg1*a151+cg2*a451+cg3*a551\$
 (C336) rt:rc*dttq2+tt*drcq2\$
 (C337) a152:coe*d1q2-d1q1*q2\$
 (C338) a452:ev4*(depq2+rt)+(pp+rctt)*d4q2\$
 (C339) a552:ev5*(depq2-rt)+(pp-rctt)*d5q2\$
 (C340) cm[5,2]:cg1*a152+cg2*a452+cg3*a552\$
 (C341) rt:rc*dttq3+tt*drcq3\$
 (C342) a153:coe*d1q3-d1q1*q3\$
 (C343) a453:ev4*(depq3+rt)+(pp+rctt)*d4q3\$
 (C344) a553:ev5*(depq3-rt)+(pp-rctt)*d5q3\$
 (C345) cm[5,3]:cg1*a153+cg2*a453+cg3*a553\$
 (C346) rt:rc*dttq4+tt*drcq4\$
 (C347) a154:coe*d1q4-d1q1*q4\$
 (C348) a454:ev4*(depq4+rt)+(pp+rctt)*d4q4\$
 (C349) a554:ev5*(depq4-rt)+(pp-rctt)*d5q4\$
 (C350) cm[5,4]:cg1*a154+cg2*a454+cg3*a554\$
 (C351) rt:tt*drcq5\$
 (C352) a155:coe*d1q5\$
 (C353) a455:ev4*(depq5+rt)+(pp+rctt)*d4q5\$
 (C354) a555:ev5*(depq5-rt)+(pp-rctt)*d5q5\$
 (C355) cm[5,5]:cg1*a155+cg2*a455+cg3*a555\$

(C356) diff:cp.m+m.cm\$
(C357) diff:ratexpand(diff);

[	0	0	0	0	0]
[]
[	0	0	0	0	0]
[]
[	0	0	0	0	0]
[]
[	0	0	0	0	0]
[]
[	0	0	0	0	0]

(D357)

(C358) closefile(Ccsub1)\$

■